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EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

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PRESSURES ON THE TEETH OF SKEW GEARS.

By V. LEHEL.

By the term "skew-gear drives" is generally meant ordinary helical gears meshing with one another, their axes not being in the same plane. Although much attention has been devoted to the investigation of the conditions of ordinary helical gear drives, not much information is available concerning skew gears. Due to this, the employment of skew gears has, hitherto, been always attended with a certain risk, and it was left almost exclusively to the personal experience of the designing engineer to select the dimensions of the gears of a skew-gear drive, or to decide if the transmission of power through skew gears was a practicable proposition at all in a particular case. The present article is an attempt to find a basis for the dimensioning of skew gears similar to that used for the calculations of ordinary spur or helical spur gears. It is hoped that this will help to eliminate uncertainty, and that it will, perhaps, make it possible even to employ, with certain limitations, skew gears for the transmission of outputs of an order usually transmitted by spur gears or bevel gears only. Some text-books recommend the formula, for the dimensioning of skew gears: $P = b \times t \times c$, where P denotes the tooth load, b the face width, t the circular pitch, and c a constant factor depending on tooth form and material. Considering the known fact that the teeth of skew gears contact theoretically in one point only, it becomes evident that destruction of the contacting surface must take place considerably before the teeth would fail due to bending, and it is obvious that a formula of this type, based, as it is, on the calculation of bending, cannot be suitable for design; neither can it be accepted for comparative purposes. The reason for this is that, according to this formula, a greater tooth load would be permissible if the face width were increased, in spite of the fact that the stress on the one point of contact will not be relieved at all by a greater face width. In fact, parts of the teeth beyond a certain width will never even come into contact with the teeth of the mating gear.

In the present article, an attempt is made to supply a basis for the dimensioning of skew gears by calculating the surface pressure at the point of contact of two mating teeth. It is not claimed that this surface pressure alone will completely define the maximum permissible tooth pressure, as rubbing speed, lubrication and surface finish will undoubtedly also have an influence, but it appears evident that surface pressure plays a very important part, very likely the most important part of all the factors in the definition of permissible load. In cases where slip is moderate and not much in excess of the slip occurring in ordinary spur gears, surface pressure may certainly be used, as is the case with spur gears, as a basis for dimensioning, making use of such figures as are available in the literature of the subject.* In cases where slip considerably exceeds the figures usual in spur-gear drives, surface pressure may still furnish a reliable basis for comparison. In the latter case, the values of surface pressure used in the calculation of ordinary spur gears may be serviceable if certain reductions be made on account of rubbing. In either case, the values allowed for spur gears may be regarded as absolute maxima which should not be exceeded in skew gears in any circumstances.

Fig. 1.

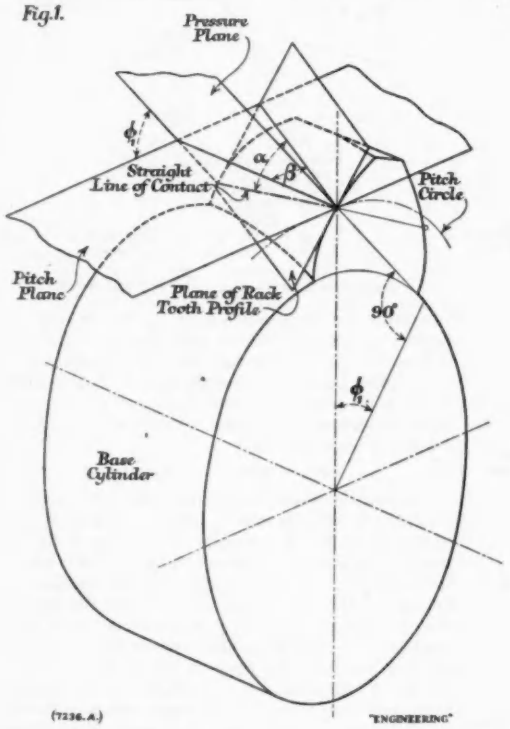


Fig. 2.

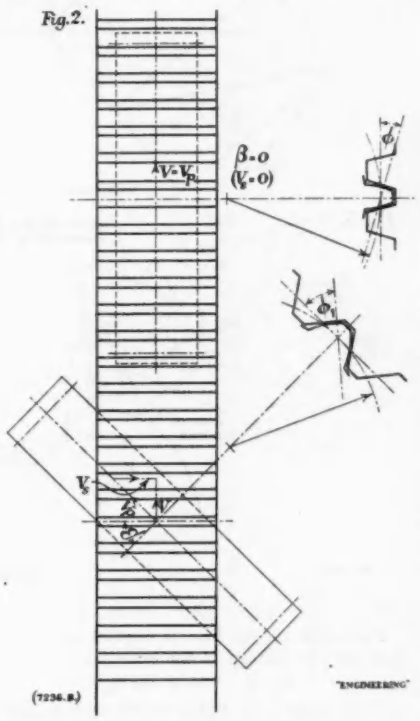
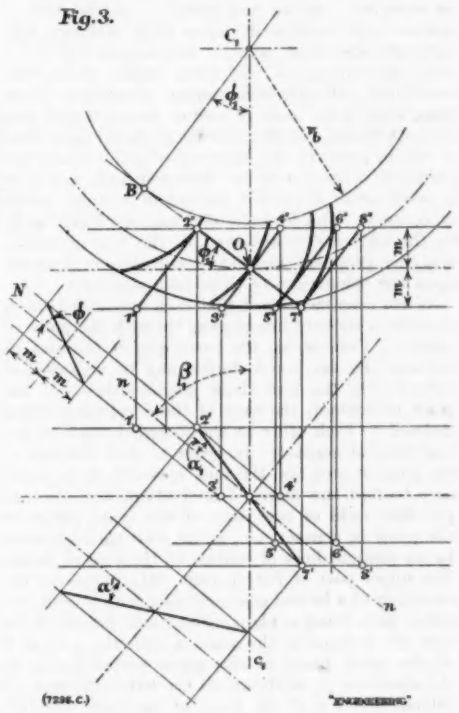


Fig. 3.



A few examples given at the conclusion of this article offer suggestions regarding the actual figures permissible.

In discussing the proposed method of calculation, it may be well to recapitulate some of the most important characteristics of skew gears. It is well known that involute teeth may be formed by a rack the tooth profiles of which are straight lines and are perpendicular to the pressure line. In this process, that circle of the gear which has the same peripheral speed as the rack is called the pitch circle, and the pitch line of the rack is the one which is a tangent to this circle and is parallel to the direction of the movement of the rack. If we are considering not an infinitely narrow gear but one having a finite dimension in the direction of its axis, it may be regarded as composed of infinitely narrow elementary gears put side by side, each one of which has been formed by a corresponding rack. If these elementary gears be assembled in such a manner that the intersections of the tooth profiles of the co-ordinated racks with the pitch plane, defined by the pitch lines of the individual elementary racks, take place along a straight line including the angle β with the direction of the axis of the gear, a helical gear is created with the helix angle β, Fig. 1. It is easy to see that the pressure lines of the elementary gears and racks will form one common plane, called in what follows the pressure plane, tangent to the base cylinder, composed of the base circles of the elementary gears, and including the angle ϕ_1 with the pitch plane of the rack. As this pressure plane is built up of the individual pressure lines, it is evident that contact between the teeth of the rack and gear will always take place along the line of intersection of this plane with the teeth of the rack. These teeth, however, also have plane surfaces, and the line of intersection must, therefore, be a straight line, including the angle α with the line of intersection of the pitch plane and pressure plane, and intersecting it at the point where the lines of intersection of the pitch plane, profile plane and pressure plane meet. It is a very important fact, though it may appear somewhat strange at first sight, that the lines of contact between the teeth of rack and gear are straight lines, which are also contained by the curved surface of the teeth of the gear built up of involute profiles.

A gear of this description may also mesh with a rack in such a manner that the rack will perform, besides its peripheral motion, another motion in the direction of the axis of the gear. The resultant of these two motions may include different angles with the axis of the gear, and the correct meshing of any number of helical gears having different helix angles with one and the same rack in this way can be imagined. It is also possible to imagine the movement of the rack composed of two movements in such a way that one component movement occurs in the direction of the teeth and the other in a peripheral direction, as shown in Fig. 2. It is evident that, assuming a very wide rack, the first movement will have no influence whatever, and meshing will take place as if a rack of the helix angle β and pressure angle ϕ_1 would engage with the helical gear, where the well-known relation obtains:—

$$\tan \phi_1 = \frac{\tan \phi}{\cos \beta} \quad . \quad . \quad . \quad (1)$$

ϕ being the pressure angle of the rack in a plane perpendicular to the direction of the rack teeth. Contact between rack and gear, in this case, will also occur along the straight lines of intersection between the profile planes of the rack and the pressure plane having the inclination ϕ_1. It may also be assumed that the rack is not a solid body, but is built up of geometrical planes having no thickness. The surface thus obtained is a rack when seen from either side. It may be imagined that this phantom rack engages with one gear on either side, that is, one above the phantom rack and the other

* See Dr. G. Schlesinger, "Modern Methods of Spur-Gear Calculation," ENGINEERING, vol. 142, page 457 (1936).

one below it, in such a way that the teeth of one gear extend into the gaps formed inside the teeth of the rack, themselves extending into the gaps between the teeth of the other gear. The axes of these two gears may, in general, include different angles β_1 and β_2 with the direction of the teeth of the rack. In this case, both gears are in correct mesh with the rack. If the two gears are rolled on the rack to a position opposite each other on either side of the rack surface, the straight inclined lines of contact of the two gears with the rack profile planes intersect one another inside these planes. The line of intersection of these two straight lines is a locus which is on both contact lines at the same time; hence this is the point in which the teeth of the two gears contact, and the intervening plane of the rack-tooth profile forms a common tangent plane to both of these tooth surfaces at this point of contact. As both gears are in correct mesh with the rack, it is also clear that the teeth of the gears will not cause interference one with the other, and that the conditions of contact will be maintained as described. As the two gears rotate, the lines of contact will continually alter their position, and naturally also their point of intersection will travel over the surface of the tooth profile plane, but conditions will otherwise remain unchanged, there being always one point of contact between each pair of tooth flanks. If this contact produces more than a certain pressure, the material of the teeth at the point of contact will be flattened and will give a small area of contact instead of a single point of contact. The formulæ of Professor Herz apply to the size of this area and to the unit pressure, and the proposed method of calculation is based upon the calculation of these unit pressures.

It has been mentioned that each contacting tooth contains a straight line passing through the point of contact. Considering the small size of the area of contact, the two tooth flanks may be regarded as cylinders in the immediate neighbourhood of the point of contact, the axes of these cylinders being inclined to each other at the included angle of the two lines of contact. In order to find the size of the contact area and the unit pressures, it is necessary to find this angle of inclination, and also the principal radii of curvature of the tooth flanks at the point of contact, *i.e.*, in the two planes normal to the straight lines of contact at the contact point. The upper part of Fig. 3, page 221, represents the elevation of a helical gear engaging with a rack, the lower part being a plan. The tooth flanks of the rack are inclined at the angle ϕ with the normal N of the pitch plane in the plane perpendicular to the direction β_1 as shown on the left. The lines of intersection $n\,n$ of the flank of the rack with the pitch plane include the angle β_1 with the axis of the gear. The planes perpendicular to the axis of the gear, and shown by their traces $1'2'$, $3'4'$, $5'6'$, $7'8'$, intersect the flank of the rack along the lines $1''2''$, $3''4''$, $5''6''$, $7''8''$. These lines are rack-tooth profiles, engaging with the involute profiles of the gear obtained from the intersection with the same planes. Contact between the rack and gear profiles occurs always in the pressure plane, represented by its trace B O, tangent to the base circle of the radius r_b of the gear. The pressure plane being perpendicular to the plane containing the elevation, its trace will also be the projection of the line of intersection of the tooth flank of the rack and of the pressure plane along which the teeth of rack and gear make contact. This line of contact may be seen in the plan, its position being defined by the projections $2'$ and $7'$ of the points $2''$ and $7''$. In plan, the projection of the line of contact makes the angle α_1 with the line $n\,n$, the actual size of this angle being shown by projection as the angle α' at the bottom of Fig. 3. The size of this angle may be found from the construction shown in Fig. 4. It will be seen from this figure that

$$\tan \alpha' = \frac{m}{(p+q)\cos \phi},$$

where

$$p = \frac{m \,.\, \tan \phi}{\tan \beta_1} \text{ and } q = \frac{m}{\tan \phi_1 \,.\, \sin \beta_1},$$

from which, substituting,

$$\tan \phi_1 = \frac{\tan \phi}{\cos \beta_1}. \quad \text{(Also see equation (1)).}$$

CONTACT PRESSURES ON SKEW-GEAR TEETH.

Fig. 4.

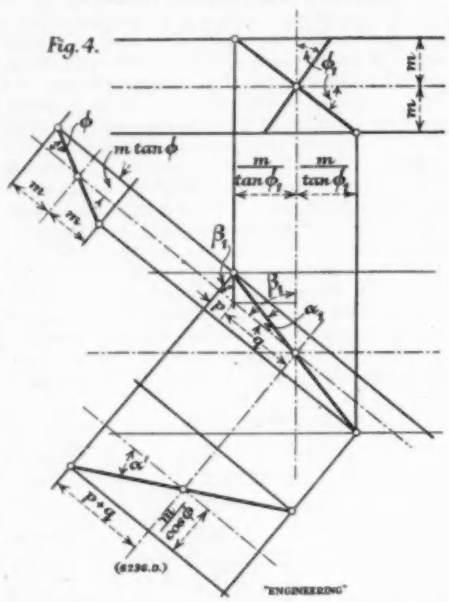
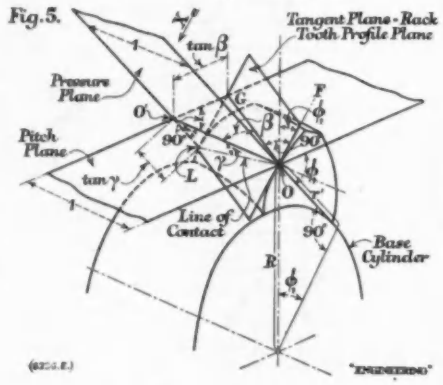


Fig. 5.



and $$\tan \alpha'' = \sin \phi \,.\, \tan \beta_1 \quad . \quad . \quad (2)$$

The angle of the line of contact of the mating gear may be defined in the same way:

$$\tan \alpha'' = \sin \phi \,.\, \tan \beta_2$$

and the angle α, included by the two straight lines of contact intersecting at the point of contact, will be

$$\alpha = \alpha' + \alpha''.$$

It is obvious that this angle will remain constant during the rotation of the gears, because neither the inclination of the plane of the tooth flanks of the rack nor that of the pressure plane will be changed, and therefore the lines of contact alter their position only but always remain parallel. To define the surface pressure, it is also necessary to know the radii of curvature of the contacting surfaces. The radius of curvature in the plane normal to the axis of the gear may be obtained immediately, since the tooth profile in this plane is an involute, for which the radius of curvature (see Fig. 5) is

$$r' = R \,.\, \sin \phi_1, \quad . \quad . \quad . \quad (3)$$

where R is the distance of the point of contact from the axis of the gear. For simplicity, it is convenient, in what follows, always to consider that moment when the point of contact is on the pitch cylinder. This assumption will not affect the validity of the statements made, and the results obtained may be easily applied also to any other point. The radius r', as stated, refers to the curvature in the normal plane of the axis. For Herz's formulæ it is necessary to know the radii of curvature in the two principal normal planes, which, as is known, contain the maximum and minimum radii of curvature. Evidently, the radius of curvature is greatest in the plane passing through the line of contact, since in this plane it will be infinite, and the minimum radius will be found in the normal plane perpendicular to the

Fig. 6.

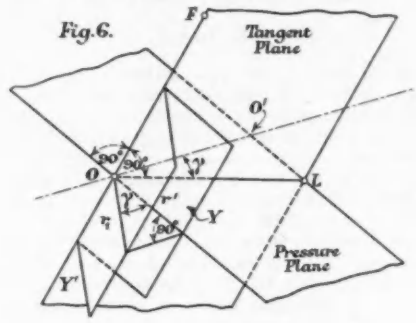
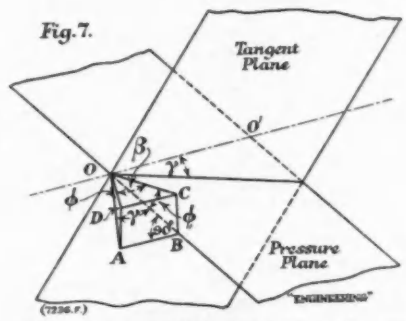


Fig. 7.



first plane, *i.e.*, perpendicular to the line of contact. From Fig. 5 it may be seen that the line of contact O L makes the angle γ with the line of intersection of the pitch plane and pressure plane. If the width of the strip of the pressure plane and of the pitch plane is assumed to be unity, as shown in the figure, γ may be expressed as:

$$\tan \gamma = \tan \beta \,.\, \cos \phi_1 \quad . \quad . \quad (4)$$

The tangent plane being vertical to the pressure plane, it necessarily also contains the normal O F of the latter, Fig. 6, which is also contained by the plane Y vertical to the axis of the gear, and in which the radius r' of the curvature of the involute is known. If the plane Y be turned about the normal O F through the angle γ, it will become, in its new position Y′, vertical to the contact line O L, and hence it will form the plane in which the minimum radius of curvature is contained. It is known from geometry that if different planes intersect at the same tangent line, the radii of curvature in the oblique sections r' will have the relation to the radius in the normal section r_1, *i.e.*, in the section containing the normal of the tangent point, expressed by the equation:

$$r_1 = \frac{r'}{\cos \gamma} \quad . \quad . \quad . \quad (5)$$

where γ is the angle between the normal section and oblique section.

Cos γ may also be obtained from the angles ϕ and ϕ_1 of the pitch plane, Fig. 7, as it may be seen, that

$$\cos \gamma = \frac{\sin \phi}{\sin \phi_1} \quad . \quad . \quad . \quad (6)$$

ϕ and ϕ_1 being known from equation (1).

If R denotes the radius of the pitch circle, substituting (6) and (3), in (5)

$$r_1 = R \frac{\sin^2 \phi_1}{\sin \phi}. \quad . \quad . \quad . \quad (7)$$

These conditions of contact being known, the surface pressures may be calculated from Herz's well-known formulæ.

(To be continued.)

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(*For Description, see Page* 223).

FIG. 1. SPERRY RAIL-DEFECT DETECTING CAR.

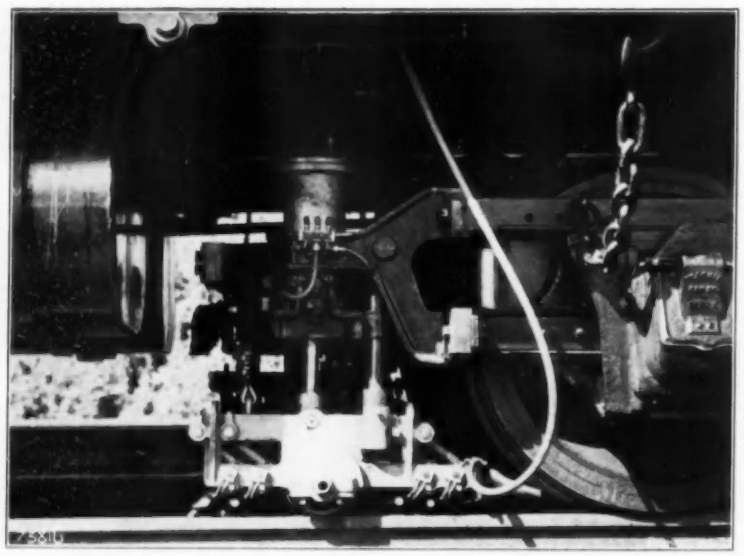

FIG. 2. FRONT BRUSH FOR PRE-ENERGISING CIRCUIT.

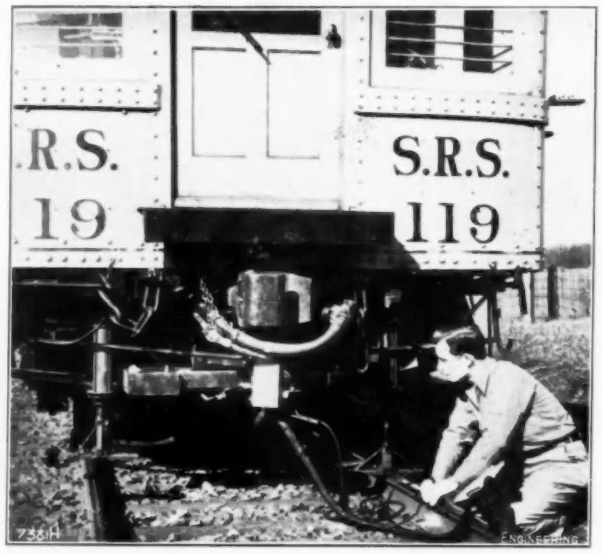

FIG. 4. HAND CHECKING OF DETECTED DEFECT.

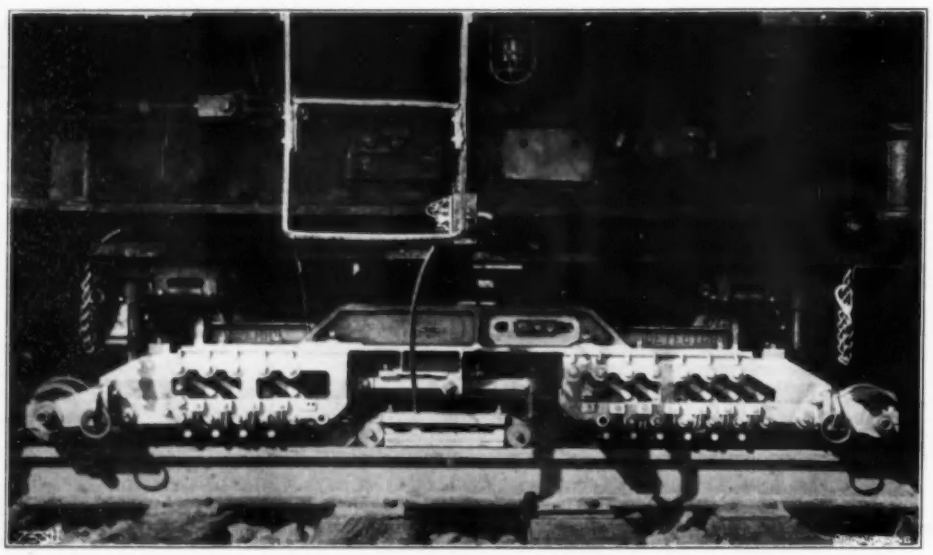

FIG. 3. REAR BRUSHES FOR DEFECT-SEARCHING CIRCUIT.

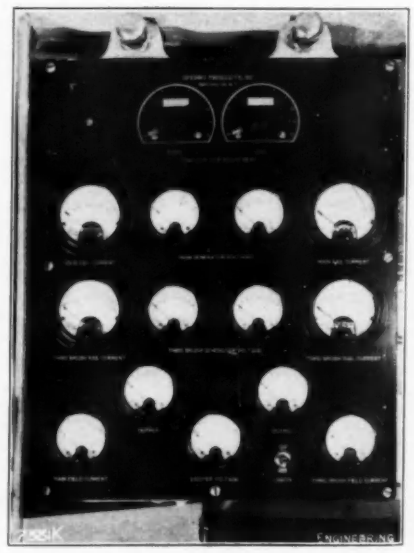

FIG. 5. RECORDING-COMPARTMENT PANEL.

(*Between pages* 222 *and* 223.)

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MESSRS. SPERRY PRODUCTS, INCORPORATED, HOBOKEN, NEW JERSEY, U.S.A.

(*For Description, see Page* 223.)

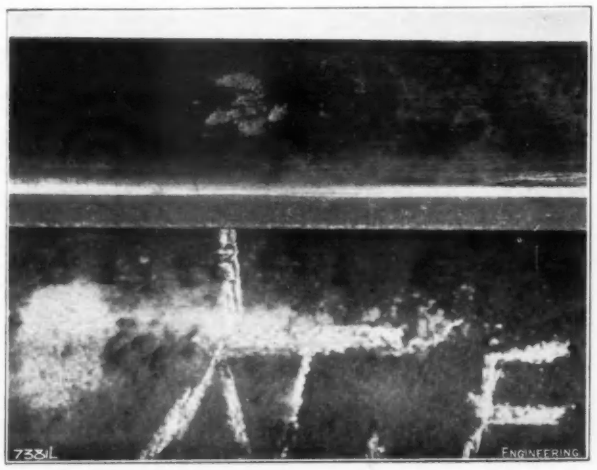

FIG. 6. SURFACE WHEEL-BURN ON RAIL.

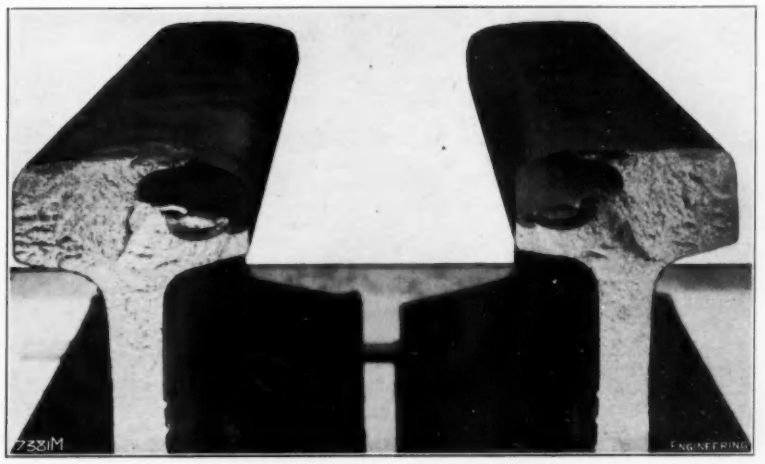

FIG. 7. FISSURE UNDER SURFACE WHEEL-BURN.

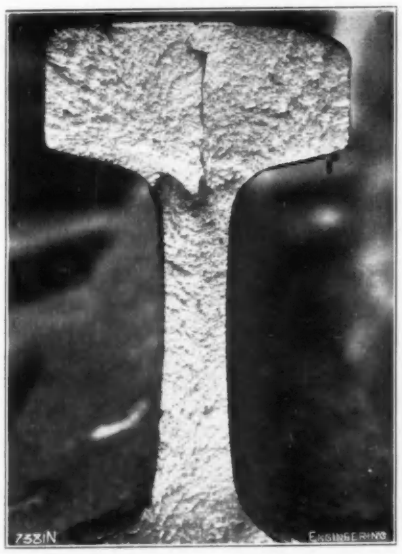

FIG. 8. HORIZONTAL SPLIT HEAD.

FIG. 9. VERTICAL SPLIT HEAD.

FIG. 10. TRANSVERSE FISSURE.

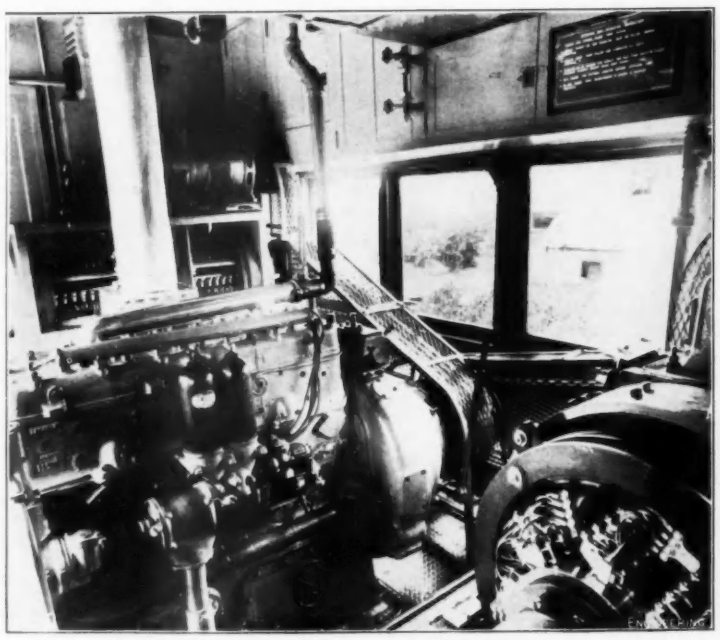

FIG. 11. GENERATOR COMPARTMENT.

FIG. 12. RECORDING COMPARTMENT.

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FIG. 13. TRANSVERSE FISSURE UNDER WHEEL-BURN.

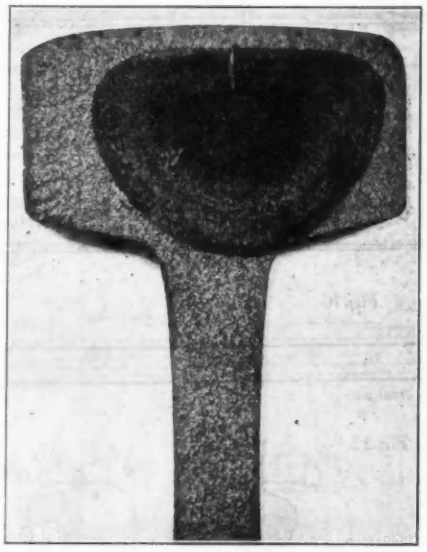


FIG. 14. CRACKED-OUT TRANSVERSE FISSURE.

THE SPERRY RAIL-DEFECT DETECTING CAR.

THE progress of research into, and the practice of methods of detection of, internal defects and visually-indiscernible surface cracks in machine and structural parts has been recorded from time to time in these columns, and the subject is now a fairly familiar one. The methods referred to are, however, generally applied on a relatively small scale, while the aspect of it dealt with in the present article is much more extensive, this being the examination of railway lines *in situ*. The extent of this examination in the United States and Canada may be judged by the fact that, between November 28, 1928, and June 30, 1940, over 597,000 miles of track were tested. In the course of this survey over 304,000 defective rails, of which 110,000 were fissured, have been detected. Such distances postulate a self-contained travelling equipment, an excellent example of which is that provided by the Sperry rail-defect detecting car, developed by Messrs. Sperry Products, Incorporated, Hoboken, New Jersey, U.S.A., the figures cited above referring to the work of such cars, the first of which was put into commercial operation on the first-mentioned date.

One of the latest of the Sperry detector cars, of which a fleet is now in existence, is shown in Fig. 1, Plate XV, a view which, while giving a good idea of its dimensions and making it clear that the body is carried on two four-wheeled bogies, does not, perhaps, convey the impression that the car is a self-propelled vehicle. It can, however, when it has to be transported from one area to another, be attached to a train having couplings and brake gear suitable for such transport. Two unusual fittings visible in Fig. 1 call for some comment. The first of these is the apparatus seen immediately behind the front bogie, *i.e.*, that to the left of the illustration, while the second is seen underneath the frame of the rear bogie, to the right. Both these attachments are brush holders connected to the electrically-operated fault-detecting installation. The front brush is seen in greater detail in Fig. 2, and the rear brushes in Fig. 3, both on Plate XV. Briefly, a searching unit between the rear brushes detects any fault as the car travels over the rails, and causes a spot of paint to be discharged where the fault exists. The fault is recorded on a moving tape inside the car and when one appears the car is stopped and a test is made, at the point indicated by the paint, by means of a hand meter, which ascertains the extent of the defect. This operation is illustrated in Fig. 4, Plate XV, while Fig. 5 on the same Plate shows the instrument panel in the recording compartment. Typical instances of the defects brought to light are shown in Figs. 6 to 10, Plate XVI, while of the two illustrations below them, Fig. 11 shows the generator compartment and Fig. 12 is a view of the recording compartment with the operator examining the moving tape.

This rough outline of the function of the car will serve until the need for its employment and the principles of its operation have been discussed, a more detailed account being given when this has been done. It is not our purpose to analyse the reasons for the increase in rail defects which has become apparent in recent years. It may be, for instance, that the heavier wheel loads and higher speeds which are becoming more common in locomotive practice may be responsible for rail fractures. On the other hand, the cause may lie in lengthened period of service of rails, or in production processes, or it may well be that the increase of defects is only apparent and not real, and that the great improvement in methods of detection have brought to light defects which would formerly escape notice. But, without attempting any explanation of causes, characteristic types of defects which occur may be briefly dealt with. The example shown in Figs. 6 and 7 is a fracture under what is known as a driving-wheel burn, that is, an area in which the surface of the metal is damaged by the sliding action of a braked wheel or the slipping action of a wheel on starting. It is stated in a report of the Bureau of Safety that wheel-burnt rails are almost invariably found near signals, water towers, in marshalling yards or wherever trains usually stop or start. The appearance of a wheel-burn is shown in Fig. 6, and in the original photograph a hair crack can be detected near it. The two ends of the rail, deliberately fractured across the burn, show, by the dark area in Fig. 7, the extent of the crack. It does not follow that a fissure invariably develops under a wheel burn nor that it always takes the form shown, but instances have been recorded of rail fracture, with subsequent train derailment, occurring at such spots. It is suggested that the flat caused by the burn causes wheel hammer blow, and this tends to set up fractures, but there appears to be a difference of opinion whether every wheel-burn should be regarded with suspicion.

The defect seen in Fig. 8, is a condition which is present in the original rail and is known as a horizontal split head. It is stated to occur in all weights and sections of rail and to be a common defect. This type is considered dangerous, since the defects may develop into a compound fissure, and the rail should, as a rule, be removed from the track as soon as possible. The defect shown in Fig. 9 is another original type and is known as the vertical split head. It is stated to be common in rails rolled from the top of the ingot, though often rails rolled from the extreme bottom of the ingot are subject to it. It is held that the vertical split head is usually due to interior seams or segregated or unsound steel in the head of the rail. Under traffic, the head splits lengthwise for distances varying from several inches to several feet. Generally, the split can be detected visually before it has grown large enough to be dangerous and sometimes rust appears in the fillet under the head. The type of defect shown in Fig. 10 cannot, however, be discovered by visual inspection of the rails and is known as a transverse fissure. The fissure always starts from the interior of the rail head and it is generally held that the starting point is a minute shatter crack or discontinuity in the steel. The growth of the normal transverse fissure appears to be a gradual process, possibly the result of fatigue, and the fissure faces acquire a high polish from the peening action set up by the passage of loaded wheels. Occasionally, however, a fissure develops very rapidly, the subsequent fracture then usually disclosing a series of growth rings, frequently accompanied by large unpolished areas, which areas indicate that sudden rupture has taken place.

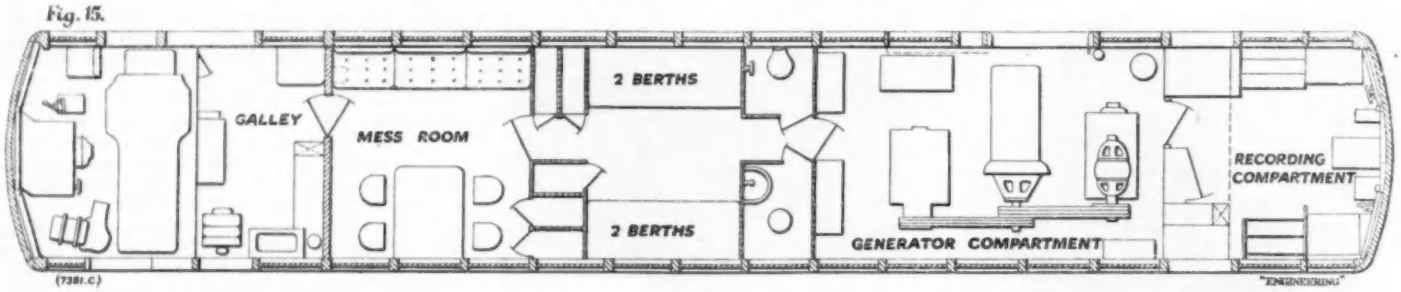
Although the area affected by the defects in Fig. 7 is not a large proportion of the cross-sectional area of the rail head, it may be very considerable, as in the example of a fissure under a wheel-burn shown in Fig. 13, and that of an internal transverse fissure shown in Fig. 14, on this page, is so extensive that the fissure shows as an external crack in the fillet under the rail head. The dark colour of the fracture in this case is due to air having entered the crack and oxidised the fractured surface. As already stated, the horizontal split head may start the development of a transverse fissure. It is impossible in this brief survey to analyse in any detail the occurrence of the several defects, but it may be mentioned that 110,000 rails out of the 304,000 defective rails mentioned earlier, had internal transverse fissures. Again, taking the year 1939, out of a total of 47,966 defective rails, 39 per cent. had transverse fissures, 4 per cent. compound fissures, 17 per cent. horizontal split heads, 33 per cent. vertical split heads, and 7 per cent. miscellaneous defects. Some of the failures other than the transverse fissure may be as dangerous as these fissures, but it may be noted that it was the occurrence of an internal transverse fissure in a rail failure which led to a disastrous accident in 1911, that caused attention to be directed to possible ways of detecting them. Many attempts were made to find a practical means, three of which, the sounding method, the X-ray method, and the magnetic method, are stated to have proved either unreliable or economically impracticable. In these circumstances, Dr. E. A. Sperry took up the question of electric detection in 1923, and, after laboratory tests, a Sperry car was put into service in November, 1928, in co-operation with the American Railway Association, now the Association of American Railroads. Since then, improvement in design has resulted in increasing efficiency.

It is not intended to trace the developments step by step, but it may be pointed out that Dr. Sperry's initial investigation was based on the ascertained fact that an internal discontinuity in a metal bar provides an area of high resistance to the flow of direct current, and that, consequently, a difference of potential occurs at the point at which the discontinuity exists. The practical application of this in the first car was its equipment with a generating plant capable of supplying a current of 2,000 amperes to each rail through sets of copper brushes. Between each set of brushes was a searching unit which consisted of a pair of differentially-wound coils having their axes transverse to the rail. When the current supplied to the brushes was flowing through a sound rail, the magnetic field above the

RAIL-DEFECT DETECTING CAR.

MESSRS. SPERRY PRODUCTS, INC., HOBOKEN, NEW JERSEY, U.S.A.

Fig. 15.



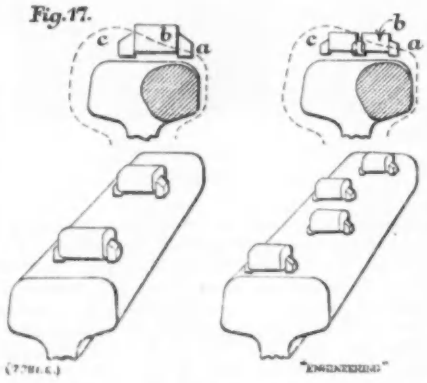
rail head was uniform and, in consequence, no voltage was generated in the coils of the searching device. A fissure in the rail head, however, by disturbing the current conditions, produced a change in flux density which set up an electromotive force in the searching unit as first one coil and then the other passed over the point of decreased flux density. By means of amplifying devices, this resultant current was caused to operate recording pens, as well as apparatus for squirting a spot of paint on to the rail at the site of the fissure.

A brief description of the latest detector car may be commenced by a reference to its lay-out, of which a plan is given in Fig. 15, above. The first compartment of the car, viz., that at the left of both Fig. 1 and Fig. 15, contains an internal-combustion driving engine and various auxiliaries. Behind this is a well-equipped galley with a stove, heater, refrigerator, sink, etc., and communicating with a dining compartment furnished on one side with a table and four chairs and on the other with a settee. A central passage-way flanked by roomy lockers leads into the sleeping quarters, which compartment contains four sleeping berths while, at the after end, a passage-way leads past a lavatory on one side and a bathroom on the other to the generator compartment. This living accommodation has proved of great service when the car is operating over long stretches of sparsely-populated territory as it obviates the necessity for stops at widely-separated stations where accommodation could be obtained. The rear end of the car is set apart for the generator and recording compartments, shown in Figs. 11 and 12, respectively. In the centre of the generator compartment is a petrol engine with a gearbox drive to its output pulley, from which multiple belts run to the main generator and auxiliary generators, and exciter. The generator has a current output of 8,000 amperes, which is a considerable increase on the original capacity.

At this point, reference should be made to Figs. 16 and 17, above. The first of these gives an outline of the two circuits through the rails, that marked *a* being the pre-energising circuit while that marked *b* is the main detecting-current circuit. The function of the pre-energising circuit first calls for comment. The car travels from right to left in Fig. 16; hence the pre-energising current is supplied to the rails in advance of the detecting current, the pre-energising current being supplied from the group of brushes illustrated in Fig. 2, direct current of 1,500 amperes being used. As a general rule, rails are more or less strongly magnetised, the natural effect of the earth's magnetic field being increased by vibration due to the pounding of the passing loaded wheels. The molecular arrangement in the rail is generally disturbed at the site of a fissure so that the detecting current, while causing re-arrangement, would not do so sufficiently to permit the searching element to detect the fault. This condition of strong magnetic poles in the rails occasionally resulted in false indications with the original equipment and these involved repetition of the run and hand testing, which naturally resulted in slower operation. The function of the pre-energising circuit now provided is, therefore, to ensure uniformity of molecular arrangement in the head of the rail prior to the introduction of the main

Fig. 16.

Fig. 17.



current at a point just before the searching element.

The use of the pre-energising current was accompanied by some other changes. It was found that the magnetic poles already referred to were of two types, viz., those within the rail head and those on its surface. The former were dealt with by increasing the testing current density in the rail to approximately 275 amperes per square inch, at which density the material in the rail head approached magnetic saturation. This was effected by the provision of generators with the large output of 8,000 amperes, *i.e.*, 4,000 amperes per rail. The superficial magnetic poles were caused by imperfect contact of the main current brushes and this has been remedied in the detector equipment now provided. The construction of both sets of brushes will be evident from Figs. 2 and 3, but in comparing these with the diagram Fig. 16 it should be noted that the direction of travel in them is from left to right, *i.e.*, the reverse of the direction in Figs. 1, 15 and 16. The searching element is clearly seen between the two groups of brushes in Fig. 3, and here, again, some modification was found necessary. The nature of this modification will be evident from Fig. 17, the sketch at the left-hand side of which shows the original arrangement of coils and that at the right hand the present arrangement. In both sections of rail the same type of fissure is shown, viz., a transverse fissure which has extended to the edge of the rail head at one side, so that there would be a crack at this side.

Obviously, the area of the rail is reduced by the fissure, so that the cross-section available for the current is irregular. Some of the current may flow through the web of the rail, but the major portion will pass through the unfissured area of the rail head, with the result that the magnetic field assumes the "lop-sided" contour shown in both sketches. It is clear from the left-hand sketch that, as one of the two coils follows the other across the fissure, it would be likely that no inductive effect would take place, but, by fitting four coils instead of two and staggering them, as in the right-hand sketch of Fig. 17, it is evident that one coil of each pair would pass through the part of the field marked *a*, *b*, while the next one would pass through the widely-different one indicated at *b*, *c*. This produces a more definite induced current in the searching element and, in consequence, a stronger indication in the recording unit. It must not be supposed that the original apparatus was ineffective; it detected faults extremely well, but the indications were somewhat uncertain in the case of large fissures situated asymetrically in the rail head and cracked out at one side. It may be of interest to note, relative to the area of fissure, that the records for 1939 show that an average of 16·6 fissures per 100 miles of track were discovered with an area of anything up to 20 per cent. of the rail head. There were 4·1 fissures between 21 per cent. and 40 per cent. in area, and 4·4 fissures between 41 per cent. and 100 per cent., both averages again being for 100 miles of track. An increased rate of growth of fissures has been noticed in the five years from 1935 to 1939, inclusive, large fissures increasing by 32 per cent. in the latter year as compared with the former. This may be due to increase in train speeds and traffic density causing the fissures to spread, but it must be borne in mind that improvements in the detector car have resulted in a more searching examination.

One of the improvements conducing to more thorough testing of the rails is connected with surface wheel-burns. These were automatically recorded as fissures on the tape, but were usually regarded as surface defects only since visual examination disclosed nothing else. As has already been indicated, however, a fissure or progressive fracture may lie under the wheel-burn and it was to detect such a hidden defect that the searching system of the latest cars has been constructed so as to be relatively insensitive to wheel-burns but responsive to any fissure or progressive fracture beneath them. The system embodies two recording pens, and the operator stops the car to examine with the hand equipment the wheel-burns indicated by both of them, but may generally inspect only those indicated by one of the pens which is, of course, known to be that concerned with surface defects and small fissures. As already stated, the exact situation of any defect is indicated by a spot of white paint automatically squirted on the rail. This spot can be seen in Fig. 4, in which the hand equipment is shown in use. The latter is a metering device which will give a quantitative indication of the fissure in terms of the percentage of the whole area of the rail head occupied by the fissure. The car, when in use for fault detection, is run at a speed of about 7 m.p.h., the record tape, seen in front of the operator in Fig. 12, moving 0·0625 in. per foot of car travel. The recording compartment is fitted with various controls, and with the panel seen in Fig. 5. It may be of interest to note that two of the outer instruments at each side of the panel are concerned with the right and left rails, respectively, the top instrument showing the main detect-

ing current and the middle one the pre-energising current. The two outer instruments at the bottom show the field currents for the main and auxiliary generators. Of the instruments in the centre of the panel, the two upper ones are voltmeters graduated to 4 volts for the main generator, and the two middle ones are similar meters for the auxiliary generator for the pre-energising current and are graduated to 8 volts. The pair of instruments below the four voltmeters show the output of the pen-relay devices and are graduated up to 25 milli-amperes. The lowest centre instrument shows the exciter voltage up to 200 volts. Direct current is used throughout. At the top of the panel is a pair of cut-out adjustment switches.

The above article, although not containing a fully-detailed description of the detector car, will serve as an indication of the present position regarding the detection of rail defects in the United States. It may be noted, in conclusion, that some 8,100 miles of track were examined by Sperry detector cars before Their Majesties King George and Queen Elizabeth travelled in the Royal train on the occasion of their visit to Canada and the United States in 1939.

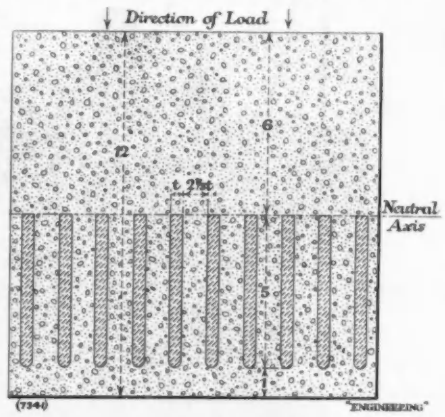
GLASS-REINFORCEMENT FOR CONCRETE.

ALTHOUGH we do not generally describe new machines, products, or systems of construction until they have been put to practical use, we deal below with a novel proposal to use strips of glass instead of steel rods or bars for reinforcing concrete, since it appears to offer the possibility of reducing materially the present heavy demands for steel. The proposal is not merely theoretical, since sufficient glass-reinforced concrete has been made to enable tests to be carried out on it; the method has also been patented. Glass-reinforced concrete has been developed by Mr. A. W. Soden, A.R.I.B.A., and Mr. John A. Lincoln, both of whom are architects and, therefore, familiar with many types of structure in which reinforced concrete is employed. A natural assumption by those hearing of this method of reinforcement for the first time would be that Armourplate glass was employed, particularly as the glass for the test beams has been supplied by Messrs. Pilkington Brothers, Limited, 63-65, Piccadilly, London, W.1. This, however, is not the case, since, although, as is well known, Armourplate glass can carry considerable bending loads, its cost would nullify one of the advantages claimed for glass reinforcement, namely, that of reduced cost; the glass used is of an ordinary type. We may now examine briefly the reasoning on which the inventors base their design.

In the first place, Young's modulus can be taken as 2,000,000 lb. per square inch for concrete and 10,000,000 lb. per square inch for glass. The limiting safe stresses may be assumed to be 600 lb. per square inch for concrete in compression and 2,500 lb. per square inch for glass in tension, this latter figure referring to glass which has a fire-finished surface. As Young's modulus for glass is five times that for concrete, the relative compression and extension to give these stresses will be proportional to 600 and $\frac{2,500}{5}$ or, 600 and 500 above and below the neutral axis, respectively. With a beam of depth d, therefore, the neutral axis will be situated at a distance $\frac{6\,d}{11}$ from the upper surface of the beam and there will be a distance of $\frac{5\,d}{11}$ below it.

The total depth being divided by the neutral axis in the ratio of 6 to 5, the width of the concrete compression zone being indicated by b and the width of the glass tension zone by y, a relation may be established between the areas of the two zones, as follows: Since the compressions in the concrete must just balance the tensions in the glass, the two sides of the equation may be set out as $\frac{600}{2} \times 6\,b = \frac{2,500}{2} \times 5\,y$, or, simplified, as $36\,b = 125\,y$. The width of the glass tension zone is, then, $y = \frac{36\,b}{125} = 0{\cdot}288\,b$. In other words, the stresses will be balanced when the width of the glass section is only 0·288 times the width of the concrete section. This is provided for by making the beam of uniform rectangular cross section and embedding strips of glass up to the required total area in the portion of the concrete lying below the neutral axis. This area is obtained when the strips of glass are situated vertically and are spaced so that the distance between them is 2 times their thickness. Their depth is in the 6 to 5 ratio referred to above, but the concrete is carried below their lower edges in order to provide a protective cover. The arrangement is shown diagrammatically in the accompanying illustration. Although the upper edges of the strips are shown in this drawing as terminating at the neutral axis, they actually project a little way above it, the reason being that the upper edges are cut and, in consequence, may contain starting points for cracks if subjected to tension. The lower edges, on the other hand, are rounded, this finish being known as the selvedge and constituting the state in which the glass is left by the manufacturing process. The other surfaces of the glass are also fire-finished, that is, are more or less wavy, and not polished like plate glass.

The tests made on concrete beams reinforced by glass strips may now be referred to. The beams



were all of rectangular section, 12 in. wide by 4½ in. deep, the glass strips averaging $\frac{1}{16}$ in. thick by 2¼ in. deep, and having their lower edges flush with the underside of the beam, *i.e.*, there was no concrete "cover" at the bottom. The concrete was a 1 : 2 : 3 mix of rapid-hardening Portland cement, well-graded clean river sand and ¾-in. ballast. For specimen No. 5, ½-in. ballast was used for the concrete between the glass strips. A wetter mix was employed for the lower part of the beams to facilitate consolidation. Five bending tests were made on beams 4 ft. 6 in. long in a Riehlé testing machine. The beams were supported at 4-ft. centres, plywood strips being placed over the knife-edges to prevent local crushing of the glass, and loads were applied at a distance of 15 in. from each support. Two impact tests were made on beams 2 ft. 3 in. long supported at 1 ft. 9 in. centres on plaster of Paris beds, 1 in. wide, the test being applied by dropping a 16-lb. weight from various heights. The results of these seven tests are summarised in Table I.

TABLE I.

Specimen No.	Reinforcement.	Bending Moment.		Design Moment (Soden).	Factor of Safety.
		First Crack.	Failure.		
		Lb.-In.	Lb.-In.	Lb.-In.	
1	10 strips, 1¼ in. pitch	56,300	64,800	26,700	2·43
2	Do. ..	60,500	61,800	26,700	2·31
3	6 strips, 2 in. pitch	34,500	45,300	16,000	2·83
4	Do. ..	43,800	45,100	16,000	2·82
5	10 strips, 1¼ in. pitch	57,800	63,600	26,700	2·38
6	Do. ..	—	At 16 lb. from height of 6 ft.	—	—
7	6 strips, 2 in. pitch	—	Do.	—	—

Deflection readings made during the bending tests showed no appreciable deflection at one-third of the failing load. Failure occurred suddenly and was of the type usually obtained with brittle materials. On reaching the maximum load complete collapse occurred, as distinct from the failure of steel-reinforced concrete with which complete collapse does not occur until some time after the maximum load has been reached. The factor of safety for specimens No. 3 and No. 4 is comparable with that of steel-reinforced concrete under similar tests, but that for specimens No. 1, No. 2 and No. 5 is somewhat lower.

The impact tests compare unfavourably with ordinary reinforced concrete. Specimen No. 6 was tested by first dropping the 16-lb. ball from a height of 6 ft. This caused slight cracking in some of the glass strips. A second similar test caused very appreciable cracking of the glass; the upper surface of the concrete was not damaged. It will be noticed from Table I that this beam contained ten reinforcing strips, as against the six strips in specimen No. 7. The latter beam was not affected when the ball was dropped from a height of 4 ft., but when it was dropped from 6 ft. complete failure occurred. Crushing tests on cubes of concrete similar to that used in the beams gave an ultimate strength in direct compression of 3,920 lb. per square inch. The specimens were, in all cases, tested after curing for seven days. An inspection of the tested beams at Messrs. Pilkington's Piccadilly office showed that the bonding of the concrete to the glass was excellent.

The tests referred to above were carried out by Dr. W. S. Marshall, B.Sc., A.M.Inst.C.E., at the Structural Laboratory of the City and Guilds College, South Kensington, and were made on the suggestion of Mr. E. H. Paisley, the A.R.P. Engineer to the Royal Borough of Kensington, with a view to investigating the possibilities of using the method for air-raid shelter construction. Dr. Marshall concludes his report by expressing the opinion that, for static loading of such intensity that the reinforcing strips do not need to be of closer pitch than 2 in., glass provides a good substitute for steel, but he recommends that it should not be employed in cases where there is any likelihood of impact loading. This would apparently restrict the use of glass reinforcement, seeing that for air-raid shelters impact loading is a likely condition. It is possible, however, that careful design of such shelters may yield satisfactory results. It is admitted that there are other difficulties, such as the liability of the beam to yield without warning, and perhaps limitations in the length of the glass strips at present available, but further investigation is proceeding in these as well as other directions. It would seem, however, that the expedient of using glass instead of steel in this particular way should not be dismissed on account of its novelty without further consideration and investigation.

THE FUTURE OF BRITISH CIVIL AVIATION.*

(*Concluded from page* 207.)

Economics.—The Brown Committee recognised that a lot of money will have to be spent on British civil aviation if it is to grow worthy of the British Empire. The best distribution of the money over the various branches of civil aviation is the first problem in economy which the controlling authority encounters. This seems to fall into two classes: economy in construction and economy in operation. Among the former are the problems of the production engineer—the degree of special tooling proper to a given contract, the choice of easily obtained materials, the avoidance of complicated sections and joints. These are all problems which have received close *ad hoc* study in recent years, but I am not sure that the special civil problems associated with the production of only a limited number of a given type have received sufficient study in this country. Problems of this kind appear to be capable of fairly precise definition, and the place for their solution is in the constructor's works and drawing offices.

The problems of economy in operation appear to be much more complex. We have moved a long way from the old ton-miles per gallon basis. This formula takes no account of the aeroplane's chief asset, speed, and even when speed is incorporated in the formula, to use it as a criterion would be to over simplify the problem. Economy in operation is, in general, bound up with the route conditions—the terrain, the weather, the number of stops available, the size and nature of aerodromes, the class and volume of traffic. Given such data, it may be possible to work out the best speed of operation and decide whether one should use a large number of small aeroplanes, a small number of large ones, or an intermediate number of medium-sized ones. At present, the method of making this sort of estimate is rough and ready and I think there is room for some economic research. The civil aviation authority should include a small staff charged with the duty of studying air-line economics, and trying, with the aid of statistical and probability theory, to reduce air-line economics to a science. There is already an extensive literature, mainly foreign. Probably the most significant document of all is a report to the Congress of the United States from the United States Maritime Commission. The commission made a careful preliminary study of trans-Atlantic costs. Confining themselves to fuel, crew, and depreciation costs, the commission found that air transport was likely, in the near future, to be operated at a cost equal to or possibly less than that of a marine super-liner. Their figures suggested that by using very large aircraft of 250,000 lb., the operating costs might

* Summary of the Wilbur Wright Memorial Lecture of the Royal Aeronautical Society, delivered on May 30, by Dr. H. Roxbee Cox.

be half those of the super-liner. The calculations could not be, and were not, taken as comprehensive. They were, however, sufficient to lead the Maritime Commission to conclude "that American vessel owners should not build super-liners, but that they might well give attention, in the field of high-speed passenger and express transportation, to trans-oceanic aircraft."

The solution of the problem of operational economy for some particular route will generally include a set of minimum performance figures required of the operation aeroplane. The designer then has a problem in economics of a different kind. He has to produce the required performance in the most efficient way. His problem can, perhaps, be illustrated by an example. The primary quantities given may be taken to be useful load, range and power plant. The designer may design a superbly streamlined fuselage, with thin wings of high aspect ratio attached to it. Such an aeroplane might well have a low skin-frictional drag coefficient and low induced drag. Is it possible to modify it in such a way that overall performance will be increased? The answer depends on the class and size of aeroplane, but the following effects should be remarked.

Suppose the aspect ratio is reduced, other things remaining, so far as is possible, the same. Then the wing structure weight is reduced and the induced drag rises. There is no reason to suppose that any change in skin-friction coefficient or wetted area is involved. The reduction in structure weight means that either the useful load could be increased, or the range increased, or the power plant increased. In the first two cases, the top speed would be very slightly reduced on account of the increase in induced drag, and for the same reason the take-off would be slightly poorer. Increase in power plant is not a very practicable possibility, as only increases in "jumps" are possible; but this means of taking advantage of the weight saving is of interest as it shows that the adverse effect on speed and take-off due to decrease in aspect ratio may well be more than counteracted by the increase in power. There is, however, another way of taking advantage of the weight saving. If useful load, range and power plant are kept constant, the reduction in structure weight leads to a reduction in all-up weight, so that for the same wing loading the size of the aeroplane, and so the wetted area, can be reduced; this reduction may possibly counterbalance the increase of induced drag already referred to.

We have supposed that the thickness/chord ratio of the wings remained constant when the aspect ratio was changed. Increase in this ratio produces simultaneously a further decrease in structure weight and increase in drag coefficient. The effects of this further change can be discussed in the same way as the aspect-ratio change and may or may not result in a net gain. In a detailed and quantitative examination of the problem, further effects of the changes will become apparent—for example, the engine nacelles, if any, will have become less bulky relative to the wing, tending to reduce drag, while the junction area of wing and fuselage will have increased, tending to increase interference drag. Already the complexity of the problem is apparent, though I have considerably over-simplified it.

Having modified the aeroplane by reduction of aspect ratio and increase of wing thickness/chord ratio, unless the craft is a very small one it probably begins to be apparent that there is some vacant space in the wing. This space is available for some of the things hitherto carried in the fuselage—petrol, baggage, even passengers if we are dealing with craft of great size. If we can stow useful load in the wing, we can reduce the size of the fuselage, and consequently achieve a reduction in drag. We now perceive another pair of opposing influences. The more we put into the wing, the closer is the approach to the structural ideal of supporting each element of mass by an element of lift. We can imagine without much trouble the limiting case of the all-wing aeroplane in which the distributions of load and lift across the span cancel one another. Wing carriage, as opposed to fuselage carriage, is therefore structurally advantageous. On the other hand, fuselages, being usually of approximately circular section, are, on a wetted area/volume enclosed basis, much more efficient than wings. This fact, if aerodynamic efficiency is to be maintained, must be a brake on any tendency to wing carriage until the wing is so big as to carry the useful load naturally.

I think there is a widespread belief that these complicated problems of design economy can only be solved as the results of the natural development of design over a period of years. General adherence to this thesis will mean that our designs will be consistently outpaced by those of more scientifically-minded folk. I suggest, in addition to the staff concerned with the economics of airline operation, a staff concerned with research into the economics of design. This staff should be a combination of men with high-class design experience and more academic technicians.

Civil Survival in War Time.—We should first of all decide upon the organisation best fitted to direct civil aviation after the war. Having decided upon the organisation, I suggest that it should be brought into being in a skeleton form, so that the various branches may be instructed in their duties when the war ends and have such threads in their hands as may be collected in war time. This would mean the revival of certain branches of the organisation current at the outbreak of war. Given a basic structure, I would hope that the important duty of keeping the civil airworthiness regulations up to date could be resumed and the problems of civil safety studied again. It is too much to hope for a serious programme of civil research and development, but a small staff should be adapting the results of research and development on the military side to the solution of civil problems. I suggest that the developments in education and training apparent at the outbreak of war should be allowed to continue. In the operational field we should aim at the maintenance of our routes in Africa and the East, and at the re-establishment of the Atlantic route. In view of the importance of maintaining our prestige in South America, close consideration should be given to the establishment of the London-Bathhurst-Port Natal route, the first leg of which, to Lisbon, has recently been inaugurated.

On the assumption that some such scheme will be followed, we must plan for replacements of our existing air liners, and we must ensure that we do not fall behind in civil design. We must plan to have some up-to-date civil types at the end of the war, which means, if the war proves long, that we must produce new types at intervals throughout the war. Clearly the number of types must be kept to a minimum. I suggest that we should work on a small air liner suitable for the internal airways of Great Britain and suitable for duty on similar lines in the Empire; a larger air liner suitable for operation on European routes, say, of 30,000 lb. all-up weight; and a trans-Atlantic craft suitable also for adaptation to the other Empire routes. I suggest that these should be designed and built, but that when designed their conversion to military types should be immediately considered. Construction of military versions could then proceed side by side with the civil versions. I regard the conversion of military to civil types, except in one instance to be mentioned, a dis-service to civil aviation. But the reverse process can produce efficient military aircraft, as has, for example, been proved in the case of the Lockheed 14 and the Flamingo. The exception I had in mind was the conversion of a fast bomber into a mail plane, and I suggest this as a fourth job.

To the objection that to do this work would be to reduce our military effort, I would reply that the reduction would be trivial, particularly when the proposed military conversion is considered, and that the military effort is not the only one we have to make—we must maintain our communications not only because we shall want them after the war, but for the better prosecution of economic warfare and for the maintenance of our commercial prestige. Our present civil aircraft will not last for ever, and we must have replacements. The work would require the allocation of separate design staffs, but the interference with industrial man power would be minimised by the conversion basis suggested—much of the structure would be common to civil and military versions. If we do not follow some such plan as this, we shall have again to buy foreign machines to keep our air lines alive, and in an effort to buy design experience. There is another aspect which civil technical experts must not ignore. While few of the aeroplanes made for

SURFACE-HARDENING MACHINE.

MESSRS. SHORTER PROCESS COMPANY, LIMITED, SHEFFIELD.

(*For Description, see Opposite Page.*)

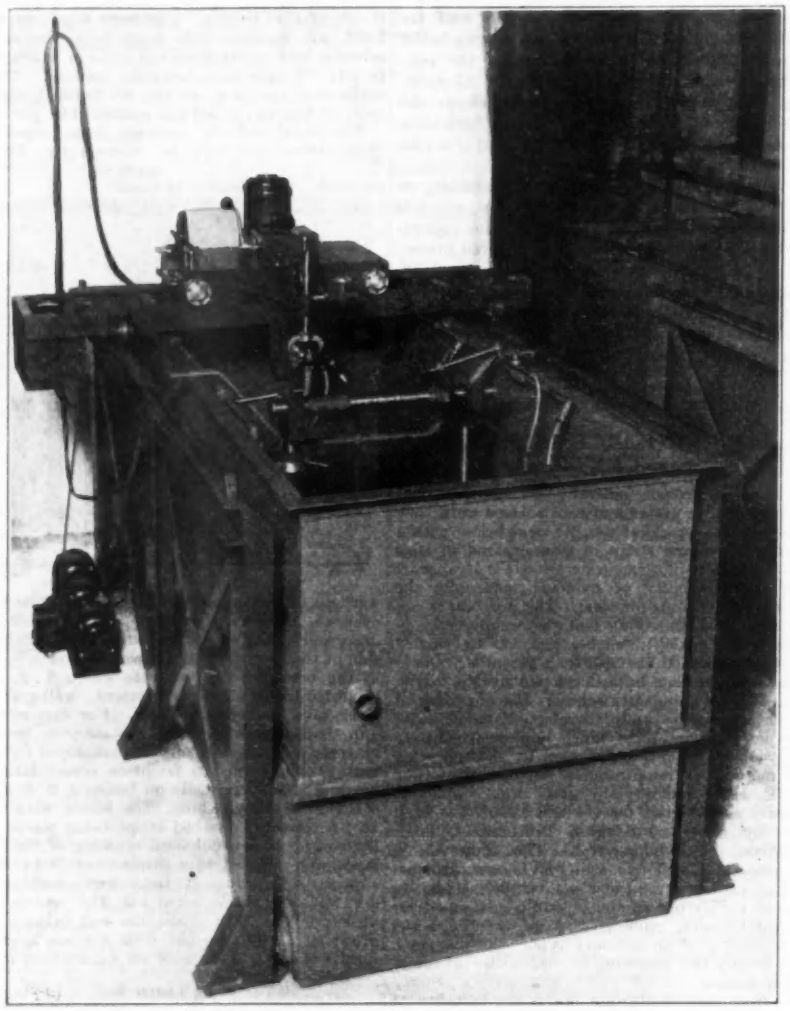
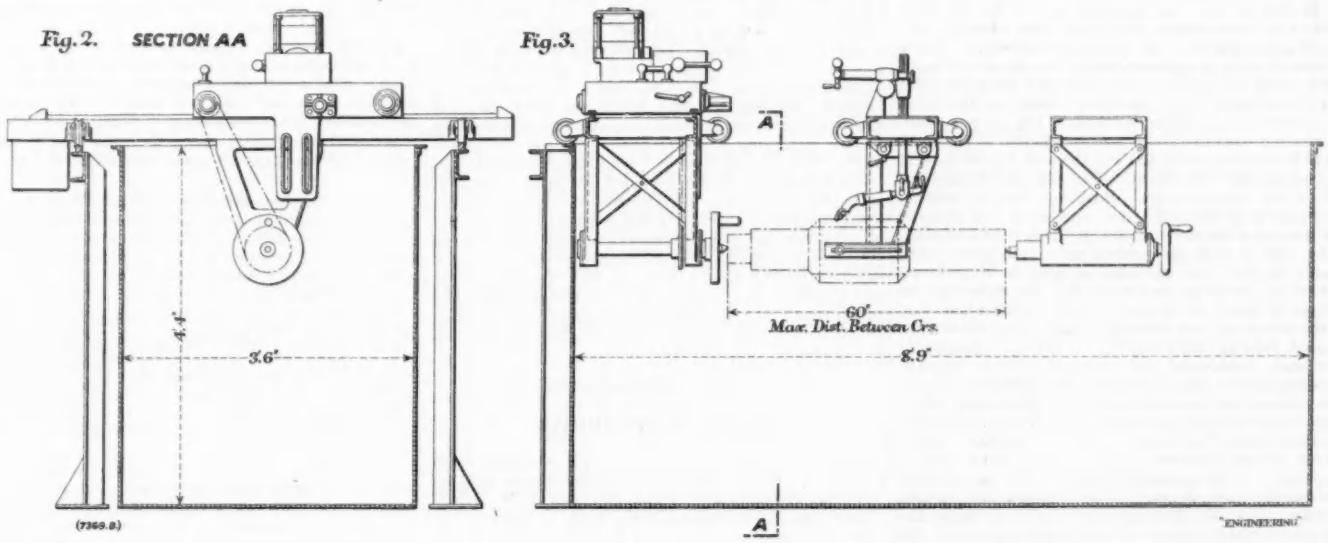


FIG. 1. HARDENING MACHINE FOR GEARS AND STRAIGHT SURFACES.

SURFACE-HARDENING MACHINE.

MESSRS. SHORTER PROCESS COMPANY, LIMITED, SHEFFIELD.



the Royal Air Force are likely to have any civil value, the ways of making them cannot fail to be of significance. Aerodynamic advances will be made, structural design will improve, engine development will continue, and the methods of construction and production will vastly improve. It is true that the accumulation of this knowledge would be available for civil construction when the military drive is over, but its application to civil aeronautics will then be too late. To apply it while it is accumulating is the way to make best use of it.

There is also a very difficult post-war problem which must be tackled before the war ends. When it ends, the productive capacity of the Empire's aeroplane factories will be tens of thousands of aeroplanes per annum; at the end of the last war, the figure for Great Britain was approximately 40,000. This order of magnitude is altogether different from that of the possible civil production required. In 1938, in Great Britain, fewer than 400 aeroplanes, mostly small ones, were built, and at the end of that year only about 1,400 airworthy aeroplanes were on the register. Even the vastly greater American civil industry only produced 3,715 aeroplanes, of which 3,122 were one- or two-seaters, in 1939. There can, therefore, be no hope of utilising for civil work, after the war, more than a small fraction of our productive capacity. What must happen to many large plants is only too obvious; a drastic reduction of the industrial side of aviation to a size comparable with peace-time military needs and the needs of civil aviation will have to be planned. A corresponding reduction, though in a less shattering ratio, will be necessary in the design staffs. We must not succumb to the temptation to employ the redundant facilities on useless labours like the conversion of military types to inefficient civil use and over-production of civil types.

LAKE SUPERIOR IRON ORES.—A report issued by the Lake Superior Iron Ore Association shows that 32,826,627 tons of ore from that area was consumed during the first seven months of the present year, as compared with 20,114,223 tons in the corresponding period of 1939. On July 31 last, there were 153 blast-furnaces in operation in the Chicago and surrounding districts, against 148 in the previous month and 102 on July 31, 1939.

GOLD MINING IN WALES.—Mining for gold has been carried on in various parts of Wales during the past 2,000 years, but has experienced many vicissitudes and has freqently lapsed for long periods at individual workings. An attempt was made some three years ago to bring again into commercial production the Roman Deep mine at Pumpsaint, Carmarthenshire, but circumstances were against the venture, and the plant has now passed into the hands of Messrs. George Cohen, Sons and Company, Limited, for disposal. The name "Pumpsaint," meaning "five saints," is linked by local legend with a stone, having in one surface five small depressions, supposed to have been caused by the heads of five saints who used it as a pillow. It is suggested by Messrs. Cohen, however, that the hollows were caused by primitive ore-crushing stamps, and that the stone was part of the very early plant used at the mine.

SURFACE-HARDENING MACHINE.

THE Shorter process for the surface-hardening of iron and steel parts has been previously dealt with in our columns, and it is therefore unnecessary to give a detailed account of its principles in the description given below of an improved machine recently introduced by Messrs. Shorter Process Company, Limited, Celtic Works, Savile-street East, Sheffield, 4. It may be as well, however, to summarise those principles by stating that the process is, broadly speaking, a mechanically-controlled method of hardening the wearing surfaces of ferrous machine parts by heating them by means of special types of burner using oxy-acetylene or similar fuels, these burners being traversed over the work as required by its form, and the work being then immediately quenched, either jets of water, or, in some cases, air, being used for this purpose. The new machine, which is identified as the "Type G.2 Shorter Surface Hardening Machine," is illustrated in Figs. 1 to 7, on this and the opposite pages and on page 230. It has been designed for hardening spur gears, bevel gears, single and double helical gears, and straight surfaces, being equally useful in the engineering workshop for either individual or mass-production work.

From the general view, Fig. 1, opposite, it will be seen that the machine consists of a motor-driven burner head mounted so that it has both cross-traverse and longitudinal-traverse in a manner analogous to the compound slide of a lathe, the traverse taking place above a tank containing the work-supporting gear and the quenching water. The burner head runs on a carriage which does not, however, run on the tank top, but on a frame external to the tank. The amount of longitudinal traverse depends, of course, on the length of the tank and, on standard machines, is merely a matter of adjustment to suit the work in hand, although it is convenient in some cases to gear up to the motor for this movement to be mechanical, when the burner head may be clamped to the cross carriage and declutched. The burner head is driven by a motor. The machine is made in two standard sizes, the largest having a tank 8 ft. 9 in. long by 4 ft. 4 in. deep by 3 ft. 6 in. wide. The smaller machine has a tank 6 ft. 10 in. long by 3 ft. 4 in. deep by 3 ft. 6 in. wide. The dimensions are internal measurements and the maximum diameter of work that can be dealt with in the two machines is 6 ft. and 4 ft., respectively. The cross-traverse of the burner head, in both machines, is 30 in., and the maximum width between the work-supporting pedestals is 17 in. in both cases. These pedestals are visible in Fig. 1, and are attached to a fabricated rotating turntable running on guides on the bottom of the tank. The work is mounted by means of cones and arbor spindles resting in Vee-blocks which are adjustable for height. It will be clear that the work shown in this illustration is dealt with by the burner head being traversed transversely and that the cross-carriage is held stationary, an arrangement which might be assumed to limit the length of work that can be handled. This, however, is not the case, since by providing a gantry along one side of the tank the burner head can be run longitudinally and longer work dealt with. This arrangement, as a matter of fact, is adopted with tanks of suitable length when extra long work, such as the ways of a lathe bed, are to be hardened.

The above adaptations do not exhaust the flexibility of the new machine. Reference to Fig. 4, page 230, which gives a view of the burner head and cross-carriage in some detail, will show that the former is provided with a slotted extension, which has no apparent function. The view, Fig. 6, page 230, makes it clear, however, that the extension is provided for carrying various attachments, one of which is therein indicated, and consists of a bracket carrying projecting adjustable fingers. This set-up is used when small spiral and helical gears are to be hardened. The axis of the gear is arranged transversely in the tank, that is, parallel to the direction of traverse of the burner head. The fingers mesh with the teeth of the gear, and, as the burner head is traversed the gears are automatically rotated. The head is driven by a motor, as already stated, but the drive can be used to rotate cylindrical parts, while the head is stationary. This is effected by a chain drive to a headstock mounted below the cross carriage and the part is then rotated very much as in a lathe, the heating and quenching jet equipment being regarded as the turning tool. Such an arrangement is shown in Figs. 2 and 3, on this page, though in the last-mentioned drawing still another adaptation of the machine is shown. In this view a large worm is seen between the centres and is rotated from the burner head as already indicated. The burner itself is, however, removed and is mounted on an auxiliary cross carriage, which is fitted with a finger-carrying bracket. The finger meshes with the worm helix, and, therefore, as the worm is rotated the burner is traversed along it. Work up to 5 cwt. in weight can be supported between centres in this manner, but above that weight support on roller steadies resting on the bottom of the tank is preferable.

Having indicated some of the possibilities of the new machine, details of its construction may be referred to. The motor on the burner head is run in conjunction with a Ward-Leonard regulating set. This is seen in the background of Fig. 1, and is mounted on a portable welded-steel bed so that it can be placed in any convenient position. The set consists of a driving motor wired to suit the particular current requirements concerned and directly coupled to a direct-current generator with an end-mounted exciter. The control panel is situated underneath one end of the cross carriage, as seen to the left of Fig. 4. The dial visible in this view is that of a speedometer and is graduated to give the rate of traverse of the burner head, from zero to 14 in. per minute. A control knob operates the shunt regulator in the generator field circuit and is so arranged that, with an alternating-current supply, its first movement operates the contactor of the Ward-Leonard set. Further movement increases the speed of the driving motor on the burner head. A fine adjustment knob is also provided, and speed control in infinitely small steps is obtained. An auxiliary switch enables the set to be stopped and re-started at any pre-determined speed without manipulation of the main control knob. The method of regulation adopted enables a final stable speed to be obtained with a variation of anything up to 10 to 1. A uniform torque is maintained throughout these

limits, the speed being, therefore, independent of the load.

The first stage of the transmission is shown in Fig. 7, page 230. The output shaft from the motor gearbox is provided with a spring-loaded saw-toothed clutch so that disengagement is instantaneous when release is effected by the cam mechanism of the knobbed lever, this mechanism, of course, also actuating the coupling movement. The fixed member of the clutch is formed with a sprocket wheel carrying a Renold roller chain led downwards over idler sprockets and then horizontally over sprocket wheels on the axles of the traversing wheels, as seen in Fig. 5, page 230. These axles each carry two wheels, the two at the right of the illustration being flat and those at the left having grooves to suit the inverted-Vee section of the back rail of the cross-carriage. Both rails are, of course, machined and the axles are carried in self-aligning ball bearings fitted with oil-tight and dust-excluding seals. The wheels are pressed on to the axles. The wheels of the cross carriage, as seen in Fig. 4, are carried in cast-iron brackets, and the axles run in bushes of phosphor bronze. The sprocket wheel seen to the left of the axle-driving chain in this illustration is used for the drive to the headstock attachment previously mentioned and indicated in Figs. 2 and 3. A second saw-tooth type clutch, actuated by the lever seen above the sprocket wheel, engages this drive. When the headstock drive is in use, the burner head is clamped to the back rail of the cross carriage by the device at the left and the traversing gear does not function. With normal traverse, the main clutch enables the burner head to be stopped and started rapidly. Since the driving motor is not reversible, the drive is stopped at the end of a working traverse and the burner head is rapidly drawn back to the starting position by hand.

The nature of the burner attachment will be clear from the several illustrations. From Figs. 4 and 6, particularly, it will be seen that universal adjustment is provided, all the motions but one being effected by means of rack and pinion gears, the exception being the vertical adjustment which has a nut and screw traverse. The blowpipe is of the non-backfiring type and is usually provided with a single-jet nozzle. The precise type of nozzle required, however, depends on the class of work to be done, as also does the form and arrangement of the quenching jets. The gas supply to the burner is through the duplex control valve on the burner head, seen to the left of Fig. 4. This valve is of the ebonite-seated type and its quick action is secured by separate cams actuated by a lever, the cam for the acetylene or other fuel gas being arranged to function slightly in advance of that for the oxygen in order to facilitate lighting-up and to prevent the oxygen impinging on the heated material when shutting off the gases. The tank is of mild-steel plate ¼ in. thick and has light angle iron stiffeners tack-welded in position. Waterways, sprays, cocks, water-level control, level indicator, and baffle bar, are provided.

BRITISH STANDARD SPECIFICATION.

Minimum Standard of Protection Against Incendiary Bombs.—In response to a demand for materials and treatments of comparatively low cost which would afford a useful degree of protection against incendiary bombs, though not necessarily as high as that required of the incombustible material conforming to specification BS/ARP No. 27, the British Standards Institution has issued a new specification designated BS/ARP No. 47. This deals with the testing of incombustible material providing a minimum standard of protection against incendiary bombs. The specification fixes a standard of protection such that materials conforming therewith will (*a*) markedly reduce the lateral spread of fire on protected surfaces; (*b*) markedly retard, or even prevent entirely, the outbreak of a destructive fire; and (*c*) markedly reduce the damage to protected timber floors, usually confining it to the slow burning and charring of a square foot or so of boarding. It is emphasised, however, that the adoption of protection to the standard fixed by the specification does not obviate the necessity for active defence against bombs by the stirrup hand pump or other fire-fighting appliance. By retarding the effects of the bomb, the time during which the bomb or the resultant fire may be effectively dealt with is appreciably extended. Copies of the specification are obtainable, price 4*d.*, postage included, from the Publications Department of the British Standards Institution, 28, Victoria-street, Westminster, London, S.W.1.

SALVAGE CAMPAIGN ON L.N.E.R.—An intensive salvage campaign organised by the London and North Eastern Railway has resulted in the collection of 1,400 fenders, 4,000 ovens from goods brake vans, and 16 tons of iron railings for disposal as scrap.

ENGINEERING TRAINING AND EDUCATION.

Treforest School of Mines.—The Calendar for the session 1940-41 of the School of Mines and Technology, Treforest, Pontypridd, Glamorganshire, has just reached us. This contains detailed particulars of the full-time, part-time day and part-time evening courses available at the School. The full-time course in mining engineering leads to a joint diploma in mining, and that in engineering to the B.Sc. degree examination of London University. Other full-time courses, in civil and structural engineering, in chemical engineering and in surveying are also available. The part-time day courses, which involve attendance for one day of six hours per week, are intended for mine managers, surveyors, mechanics, electricians, technical chemists and gas engineers. The evening courses cover a variety of engineering and technical subjects leading to National Certificate and other examinations. Post-diploma courses in engineering, mining, and science are also held and research work is encouraged. The first term of the forthcoming session begins on Tuesday, October 1, for day courses, and on Monday, September 23, for evening courses.

BOOKS RECEIVED.

United States Geological Survey. Water-Supply Paper No. 841. *Geology and Ground-Water Resources of the Harney Basin, Oregon.* By A. M. PIPER, T. W. ROBINSON and C. F. PARK, JUN. *With a Statement on Precipitation and Tree Growth.* By L. T. JESSUP. [Price 1 dol.] Water-Supply Paper No. 843. *The Floods of December, 1937, in Northern California.* By H. D. MCGLASHAN and R. C. BRIGGS. [Price 60 cents.] Washington: Superintendent of Documents.

The Design of High Pressure Plant and the Properties of Fluids at High Pressures. By DR. D. M. NEWITT. London: Oxford University Press (Sir Humphrey Milford). [Price 35*s.* net.]

The Aircraft Bench Fitter. By W. S. B. TOWNSEND. Second edition. London: Sir Isaac Pitman and Sons, Ltd. [Price 3*s.* 6*d.* net.]

Teach Yourself Trigonometry. By P. ABBOTT. London: The English Universities Press. [Price 2*s.* 6*d.* net.]

The Ohio State University. The Engineering Experiment Station. Bulletin No. 105. *The Development of Superduty Refractories from Ohio, Pennsylvania, and Kentucky Fire Clays.* By RALSTON RUSSELL, JUN. Columbus, Ohio, U.S.A.: The Director, The Engineering Experiment Station, The Ohio State University. [Price 60 cents.]

Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete Submitting Recommended Practice and Standard Specifications for Concrete and Reinforced Concrete. 7400 Second Boulevard, Detroit, Michigan, U.S.A.: American Concrete Institute. 260 South Broad-street, Philadelphia, Pa., U.S.A.: American Society for Testing Materials. [Price 1·50 dols.]

Annual Report of the Minister of Mines of the Province of British Columbia for the Year Ended 31st December, 1939. Victoria, B.C.: British Columbia Department of Mines.

The Association of Engineering and Shipbuilding Draughtsmen. Power Pumps. By C. EDWARDS. 1 Links-road, Epsom, Surrey: The Draughtsman Publishing Company, Ltd. [Price 2*s.* net.]

United States National Bureau of Standards. Handbook No. H31. *Safety Rules for the Installation and Maintenance of Electrical Supply Stations. Comprising Part* 1 *and the Grounding Rules of the Fifth Edition, National Electrical Safety Code.* Washington: Superintendent of Documents. [Price 10 cents.]

Journal of the Iron and Steel Institute. Volume CXLI. 1940. No. I. Edited by K. HEADLAM-MORLEY, Secretary. London: Offices of the Institute, 4 Grosvenor-gardens, S.W.1.

The Materials of Aircraft Construction for the Designer, User and Student of Aircraft and Aircraft Engines. By PROFESSOR F. T. HILL. Fourth and revised edition. London: Sir Isaac Pitman and Sons, Ltd. [Price 20*s.* net.]

The Iron and Steel Industry. Historical Development, Raw Materials, Manufacturing Processes, Mechanical Treatment, Alloy Steels, Chemistry and Structure, Location. By G. BROWN and L. ORFORD. London: Sir Isaac Pitman and Sons, Ltd. [Price 6*s.* net.]

United States Coast and Geodetic Survey. Special Publication No. 218. *First and Second Order Triangulation and Traverse in North Carolina* (1927 *Datum*). Volume II. By O. S. ADAMS. Washington: Superintendent of Documents. [Price 40 cents.]

Engineering Workshop Manual. For Students, Fitters, Turners and General Machinists. By E. PULL. Seventh edition. London: The Technical Press, Limited. [Price 4*s.*]

PERSONAL.

MR. W. J. PETERSEN has succeeded DR. H. J. VAN ECK as President of the Institute of British Foundrymen (South African Branch).

MESSRS. THE RUBEROID COMPANY, LIMITED, have removed to Sentinel House, 46, Southampton-row, London, W.C.1.

MESSRS. GEORGE SALTER AND COMPANY, LIMITED, West Bromwich, Staffs, have decided to close their branch office at Chronicle Buildings, Corporation-street, Manchester, for the duration of the war. The personnel has returned to the head office at West Bromwich.

MAJOR S. M. MOHR, O.B.E., M.C., has been re-elected chairman of the British Plastics Federation for the year 1940-41.

MR. W. R. HEBBLEWHITE, B.E., M.I.E.Aust., chief executive officer of the Standards Association of Australia, has been temporarily seconded to the Council for Scientific and Industrial Research of the Commonwealth for duty at the National Standards Laboratory in charge of the section dealing with the co-ordination of testing services.

MR. A. Y. PLANT, who was formerly with Messrs. H. R. Marsden, Limited, quarry engineers, Leeds, and also for a number of years with Messrs. W. H. Baxter, Limited, Leeds, has joined the staff of Messrs. George Cohen Sons and Company, Limited, and will have his offices at their Stanningley Works, near Leeds. He has had considerable experience in quarrying and mining plant.

MESSRS. THE BRITISH ALUMINIUM COMPANY, LIMITED, inform us that as from September 30 their temporary head-office address will be Oakley Manor, Belle Vue-road, Shrewsbury, Shropshire. The telegraphic address, "Cryolite Shrewsbury," and the telephone number, Shrewsbury 4451, will be unchanged. The telephone number for the sales, planning and publicity departments will be Shrewsbury 4474.

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Sump Pumps, motor-driven, two, and equipment. Public Works Department, Wellington, N.Z.; October 29. (T. 21,604/40.)

Switchgear, 110 kV, gang-operated, outdoor-type, for use on three-phase, 50-cycle supply. Public Works Department, Wellington, N.Z.; November 5. (T. 21,700/40.)

Track Jacks. With reference to the call for 350 track jacks, noted on page 189, *ante*, we now learn that the South African Railways and Harbours, Johannesburg, have postponed the closing date from October 17 until October 31. (T. 21,547/40.)

Switchgear and Transformers, comprising four switchboards and two 400-kVA transformers, three-phase, 50-cycle, oil-immersed 6,600/380 volts. South African Railways and Harbours, Johannesburg; October 14. (T. 21,795/40.)

Distribution Transformers, two, 300 kVA, three-phase. Electricity Supply Commission, Cape Town; November 12. (T. 21,801/40.)

Transformers and Relays, comprising inverse time overcurrent relays; instantaneous overcurrent relays; single-phase, 50-cycle, definite-time and auxiliary relays to operate on 12 volts direct-current. Also four outdoor-type current transformers, ratio 150/5 amperes, 15-VA. Class C, to British Standard Specification No. 81-1936, and insulated to 3,300 volts. Public Works Department Wellington, N.Z.; October 22. (T. 21,699/40.)

Steam Travelling Crane, 10-ton, for Durban Harbour. South African Railways and Harbours, Johannesburg; November 4. (T 21,793/40.)

THE SPANISH IRON-ORE INDUSTRY.—The production of iron ore in Spain during 1939 totalled 3,200,000 metric tons, compared with 2,514,000 tons in 1938 and 991,000 tons in 1937. The 1939 total, it is pointed out in *The Iron and Coal Trades Review*, just exceeds that for 1931, and is thus the highest for nine years. It was still, however, well below the total for 1930, namely, 5,517,000 tons. Just over half the 1939 output, or 1,676,000 tons, was mined in the orefields of the Province of Viscaya. Last year, 1,200,000 tons of ore were exported from all Spanish ports, compared with 1,145,000 tons in 1938 and 848,000 tons in 1937. Bilbao, the principal exporting centre, handled 742,000 tons of export ore in 1939. Up till April of the present year, ore was still being exported to the Netherlands, apart from the traditional trade with this country, but the May returns for exports from Bilbao show that all 19 cargoes despatched in that month went to the United Kingdom.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—As a result of discussions which the executive council of the South Wales Miners' Federation had with Mr. D. R. Grenfell, the Minister for Mines, at Cardiff last week, a three-point plan has been drawn up to assist the coalfield. The three main points decided upon were a levy on coal production generally to secure a fund for keeping, in working condition, the pits left idle in the main exporting areas, the transfer of unemployed miners from the export district, and the relaxation of the Order forbidding the miners now idle from taking up other work. Pits will not be allowed to become derelict but will be able to meet the demand when conditions again became normal. The discussion arose following the demand made by the exporting areas, which include South Wales, for a share of the increased home demand. There is the possibility of the home demand growing and at the moment the coalfields catering for the inland trade are producing above their normal outputs. Conditions on the market show no material change. The foreign demand has remained at a somewhat low level and what business was available was almost exclusively in the Portuguese, South American and Eireann trades. Nevertheless, in spite of the continued slackness of this section, operations at the mines have been maintained at recent levels as a good business was offering from inland users. This was sufficient to provide an outlet for the bulk of the production, with the result that sellers were not pressing and the general tone was very steady. Best large coals were only very quietly offering for early delivery, while the popular sized sorts continued to meet with a keen demand. Stem lists for these were well filled ahead, with the result that new business was not easily arranged. The bituminous small grades again attracted attention, but were scarce and firm. The dry smalls, on the other hand, were easily obtained and were dull. Cokes were active but patent fuel remained slow.

The Iron and Steel Trade.—Activity was well sustained in the iron and steel and allied trades of South Wales and Monmouthsire during the week. The demand for the various finished products was fully maintained and works were consequently assured of steady employment for some time to come.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Steel makers in this area are experiencing no trouble in obtaining sufficient supplies of raw materials, with the result that large outputs of bars, ingots, plates, and sections are being produced. There is a strong demand for basic steel, and the call for acid carbon steels has increased considerably during the past six months. Tool-steel makers are finding it difficult to cope with the demand. Firms concentrating on the production of alloy steels and special high-efficiency steels are confronted with a demand which would have been regarded as impossible a year ago; the bulk of the production is being consumed on Government work. Activity in the heavy-machinery and engineering branches is reaching a very high level. Not only are war orders numerous, but some firms report an influx of contracts for commercial products. These are notably for railway rolling stock, wheels, axles, springs, tyres, and buffers, grinding and crushing equipment, electric-generating plant, and coal-mining equipment. There is a strong demand for steel arches and cambered girders for use in place of wooden pit props. Makers of steelworks' equipment continue to be busily employed; contracts have been placed for rolling mills, hydraulic presses, forging plant, and rollers. Sheffield's edge-tool trade is actively engaged on both home and overseas orders. During the next 12 months it is hoped to export more than 7,000,000 "pieces," chiefly agricultural implements, including plantation hoes, forks, picks, spades, shovels, scythes, and hatchets for use in the production of sugar, tea, coffee, rice, maize, cotton, cocoa, rubber, palm oil, soya beans, and oranges. The greater portion of such products will go to Empire markets, including Australia, New Zealand, India, Ceylon, Burma, and Cyprus. It is also hoped to improve sales in Greece, China, the Dutch East Indies, and the Philippine Islands. Machine tools are in demand, and there is a strong Government demand for gearboxes and clutch plates.

South Yorkshire Coal Trade.—Increased outputs are reported by collieries in this area, and stocks are accumulating at some pit heads. Industrial coal is in strong demand; many firms have adequate stocks, and a winter shortage is highly improbable. Smalls are in request by electric power stations. House coal sales show a further increase. The coke market is brisk, and producers are disposing of big tonnages.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The production of iron and steel is maintained at a very high level and not only meets the more urgent needs of priority delivery claims, but provides some additional tonnage for the usual industrial requirements. Gratifying features of the present situation are the continued ample supplies of raw materials and semi-finished products; the collection of scrap has attained record proportions.

Cleveland Iron Trade.—No improvement in the meagre supply of Cleveland pig can be reported, but as ample deliveries of Midland foundry iron continue to reach the area, the scarcity of local brands is of little consequence. Occasional parcels of Scottish iron are still obtainable for particular purposes. There is still no preparation for the resumption of the normal make of Cleveland pig. The intermittent output contributes little to founders' requirements which are gradually expanding. The fixed prices of Cleveland pig are based on No. 3 description at 120*s.*, delivered within the Tees-side zone.

Hematite.—The heavy production of East-Coast hematite is hardly sufficient for the current demand and a substantial tonnage is coming forward from America. As all available hematite furnaces are in operation, the prospects of a further enlargement of the local make are remote. The pressure for full deliveries against extensive running contracts is unabated and the large and increasing needs of makers' own consuming plants are accounting for a large proportion of the production. The recognised market values of East Coast brands are ruled by No. 1 grade of iron at 131*s.*, delivered to North of England areas.

Basic Iron.—The large make of Tees-side basic iron is passing promptly into use at producers' adjacent steel-making plants. There is still no saleable tonnage and the quotation of 113*s.* remains nominal.

Foreign Ore.—The consumers of foreign ore have a larger tonnage stored than has been the case for a considerable time and as imports are better and more regular, stocks are likely to be well maintained.

Blast-Furnace Coke.—Durham blast-furnace coke is plentiful and the local consumption is heavy, but conditions are not conducive to business. Sellers have extensive contracts to execute and North-East Coast users have covered their requirements as far ahead as they care to commit themselves. The stabilised quotations remain at the level of good medium qualities at 33*s.* 5*d.* at the ovens.

Manufactured Iron and Steel.—The outputs of semi-finished iron and steel are maintained on a satisfactory scale and are supplemented by substantial imports of billets, blooms and steel bars from America. These fully cover the requirements of the re-rollers. The production of several finished commodities is reaching nearly a record level. The maximum make of all gauges of black and galvanised sheets is necessary to deal with customers' requirements and heavy-steel producing plant is operating at full capacity in order to keep pace with the needs of shipbuilding and engineering undertakings.

Scrap.—The supply of iron and steel scrap is now ample and users are taking all they can obtain in order to build up reserves.

MANGANESE-ORE INDUSTRY IN CUBA.—The capacity of the plant of the Cuban-American Manganese Corporation, at Cristo, Cuba, which now produces annually 100,000 tons of concentrated ore, averaging 50 per cent. of manganese, and 50,000 tons of 40 per cent. material, is to be increased. By January 1, 1941, the installation will produce 130,000 tons of the higher-grade concentrate. The output of the 40 per cent. manganese material will be maintained at its present level.

IMPORT LICENSING OF TURPENTINE AND PINE OIL.—The Board of Trade announces that the open general licence authorising the importation of turpentine and pine oil has been revoked with effect from September 9, 1940. Individual licences will now be required for the importation of these commodities except in the case of goods proved to the satisfaction of H.M. Customs and Excise to have been dispatched to this country before September 9, 1940, and which are imported into the United Kingdom before November, 1940. Applications for licences to import turpentine or pine oil should be addressed, together with a statement of the importer's past trade in the goods in question, to the Import Licensing Department. Forms on which the statement of past trade should be given will be provided on application to the Import Licensing Department; forms of application for licences are also obtainable from the Department or from the Offices of H.M. Collectors of Customs and Excise.

NOTICE OF MEETING.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Yorkshire Branch:* Saturday, September 28, 2.30 p.m., The Hotel Metropole, Leeds. Chairman's Address: "The Results of Recent Research on the Effects Upon Buildings of High Explosive and Incendiary Bombs," by Dr. R. H. Evans.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been great activity in the Scottish steel trade during the past week. The shipyards are all fully occupied and are very busy, and the delivery of ship plates, etc., to the various yards is, therefore, on a large scale. All other users of heavy steel are also pressing for supplies but the steelmakers are meeting the demand in a satisfactory manner. Light steel sheets and plates are in great request and orders on hand will keep plant running at full capacity for some months; in spite of this, fresh inquiries are coming in daily. In addition to the tonnage being consumed at home, a fair amount is being exported. The following are the current market quotations:—Boiler plates, 15*l.* per ton; ship plates, 14*l.* 3*s.* per ton; sections, 13*l.* 13*s.* per ton; medium plates, rolled in sheet mills, ¼ in. and thicker, 18*l.* 7*s.* 6*d.* per ton; mild-steel black sheets, No. 21-24 gauge, close annealed, 19*l.* 7*s.* 6*d.* per ton; galvanised sheets, plain, No. 21-24 gauge, 23*l.* 2*s.* 6*d.* per ton, and corrugated, No. 24 gauge, 22*l.* 12*s.* 6*d.* per ton.

Malleable-Iron Trade.—Conditions in the malleable-iron trade of the West of Scotland have not changed and as makers have a good deal of work booked, they are kept fully occupied. The re-rollers of steel bars are still extremely busy. The stocks of semies on hand are satisfactory at present as deliveries from overseas, which arrived recently, amounted to a considerable tonnage. To-day's market prices are as follows:—Crown bars, 15*l.* 2*s.* 6*d.* per ton; best iron, 15*l.* per ton; No. 3 bars, 13*l.* 7*s.* 6*d.* per ton; No. 4 bars, 13*l.* 12*s.* 6*d.* per ton; re-rolled steel bars, tested, 15*l.* 11*s.* 6*d.* per ton, and untested, 15*l.* 8*s.* 6*d.* per ton; angles and tees, 4 in. and under, tested, 15*l.* 1*s.* 6*d.* per ton, and untested, 14*l.* 18*s.* 6*d.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—In the pig-iron trade of Scotland the output is being well maintained but the requirements of industry in general are so heavy that makers are not able to accumulate any stocks. Steel makers are urgent in their demands but orders for foundry grades are still rather small. The supply of iron ore has improved considerably of late and good shipments from India and America have rendered the outlook for the industry quite satisfactory.

AMERICAN IRON AND STEEL INSTITUTE.—A special committee which will deal with U.S. Government specifications has been set up by the American Iron and Steel Institute. Its purpose will be to assist Government buying agencies in the interpretation of specifications for steel products so as to expedite defence works. It is pointed out that many existing specifications used by Government Departments are regarded as out of date and it is anticipated that the new Specifications Committee will bring the Government purchasing of steel into closer alignment with commercial practice.

ELECTRIFICATION OF VEVEY-CHEXBRES-PUIDOUX RAILWAY, SWITZERLAND.—It is stated, in a recent issue of *The Railway Gazette*, that the Vevey-Chexbres-Puidoux Railway has now been converted to the standard Swiss single-phase system of electric traction. The line belongs to a private company, but is leased to, and worked by, the Swiss Federal Railways. Between Vevey and Puidoux the speed of the new electric railcars is about 31 m.p.h., compared with only from 11 to 13 m.p.h. with the previous steam trains. On descending the maximum grade, which has an inclination of 1 in 27, the speed is not allowed to exceed 28 m.p.h.

THE LAMBERT-GARLAND MOORING BUOY.—We have received from Messrs. William McNeil and Company, Limited, 125, West Regent-street, Glasgow, C.2, a pamphlet describing the Lambert-Garland mooring buoy for ships and aircraft, for which they have been appointed British agents. The Lambert-Garland buoy is of the cylindrical type and floats with the flat surfaces horizontal, the mooring shackle being attached to a ball-and-socket swivel approximately at the geometrical centre. Conical mouths above and below the swivel allow the cables to assume a considerable angle from the vertical before they begin to cant the buoy.

SURFACE-HARDENING MACHINE.

MESSRS. SHORTER PROCESS COMPANY, LIMITED, SHEFFIELD.

(*For Description, see page* 227.)

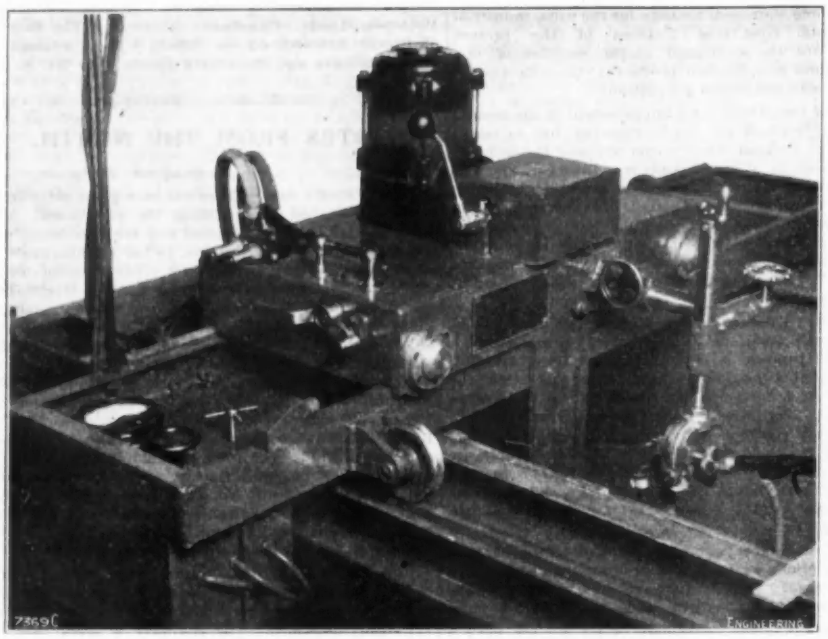


FIG. 4. BURNER HEAD AND CROSS CARRIAGE.

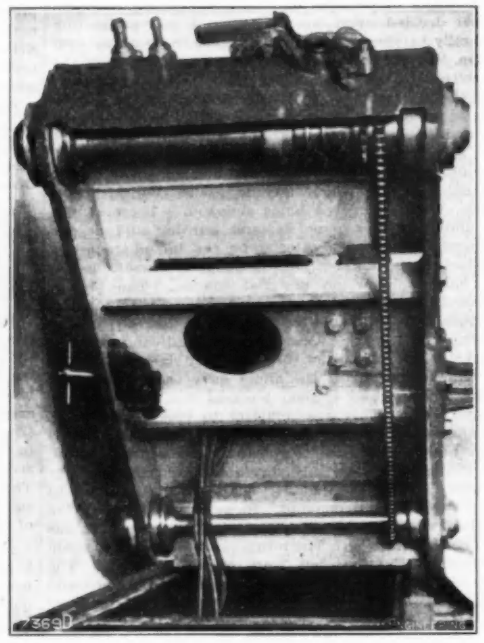


FIG. 5. UNDER SIDE OF BURNER HEAD.

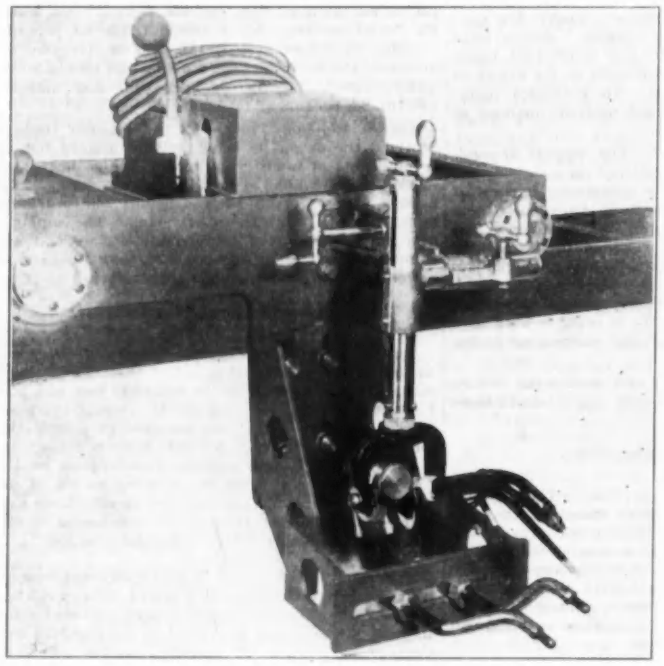


FIG. 6. ATTACHMENT FOR SPIRAL AND HELICAL GEARS.

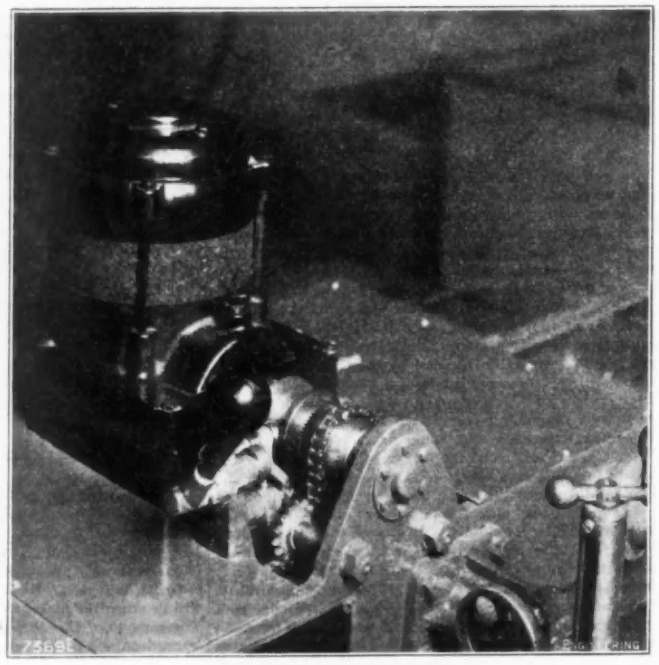


FIG. 7. DRIVING MOTOR AND TRANSMISSION GEARS.

GRINDING-ACTION THEORIES ERRATUM.—We regret that in our summary of a paper on Grinding-Action Theories, by Mr. Albert H. Dall, of the Research Department of Messrs. The Cincinnati Milling Company, Cincinnati, Ohio, U.S.A., an error occurred in the formula for length of chip which appears near the top of the centre column on page 55, *ante*. The correct formula is:

$$L = \left(R \pm r\frac{R}{N}\right)\sqrt{\frac{rt}{R(R+r)}}.$$

OLD STONE BLAST-FURNACE.—An old stone blast-furnace, called the Rebecca Stack, and situated near Lisbon, Ohio, U.S.A., is described by Messrs. E. S. Dawson and M. H. Mawhinney in a recent issue of the American journal *Steel*. The furnace, which was originally about 30 ft. in height and had a diameter of 8 ft. at the bosh, was built in 1807 and had a capacity of 2 tons of cast iron a day. Local ores were used and the fuel was charcoal, of which 200 bushels were consumed per ton of iron. It appears that, in 1832, a flood destroyed the furnace and the adjoining small works and that they have been derelict ever since.

NICKEL-CONTAINING MATERIALS IN MARINE ENGINEERING.—The Mond Nickel Company, Limited, has recently issued a publication in which are set out tabular summaries of the classes of nickel-containing materials recommended for various parts and components used in marine engineering. Details of the compositions of steels and non-ferrous metal alloys best suited for individual applications are also given. Materials are recommended for the hull, including sea cocks and valves, the stern frame and the rudder and its fittings; for the boiler room, including the fuel-supply and boiler-feed equipment, the boilers themselves and the steam lines; and for the engine room, including steam turbines, reciprocating engines and Diesel engines. Materials are also suggested for propellers, propeller shafts, bushes and brackets; for electrical equipment; for water, sewage and ventilating systems; for deck gear and fittings; for lifts and refrigerating machinery; for the equipment of dredgers; and for kitchen, laundry and hospital fittings. The metals recommended include bronzes of various types; cast irons, including Ni-Tensyl, Ni-Hard, Nomag, Ni-Resist and Nicrosive; the nickel-silver series of alloys; Inconel and other nickel-chromium alloys; eleven grades of aluminium alloys, including the "R.R." types, Y alloy, and Ceralumin; the low-, medium-, and high-nickel alloy steels; and Monel metal and other nickel-copper alloys.

ENGINEERING.

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ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines, or under, and one shilling per line up to one inch. The line averages six words. When an advertisement measures an inch or more the charge is 12*s.* per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns, of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, SEPTEMBER 20, 1940.

VOL. 150. No. 3897.

THE AIR WAR.

DURING the past ten days the air war over Britain, and especially over London, has continued with unabated intensity and with some interesting variations in method. The German attacks, originally concentrated on the riverside districts and directed against industrial targets, have become more widely distributed over the area of Greater London. In some cases, as in the daylight bombing of Buckingham Palace, there has been evidence of a deliberate selection of what a more civilised code of warfare than that of the Nazis would have regarded as non-military objectives ; but it is clear also that the more vigorous employment of anti-aircraft barrage fire has proved effective in preventing the night raiders from picking out individual targets by forcing them to operate at such heights as to preclude any possibility of taking an accurate aim. If it is still true that neither side has yet found a completely effective antidote to night bombing attacks, the reason is probably to be found in the scale of the operations rather than in any deficiency of material or of organisation. British night-flying fighters are excellent machines, handled with great skill, but the difficulty of locating and bringing to action a single bomber, wandering more or less at random in, perhaps, five thousand cubic miles of space, should not be underrated.

The counter measures against daylight raiders, however, have been effective to an extent that few would have ventured to prophesy, and consistent to a degree that leaves no doubt regarding the quality of the British fighters and their pilots, and of the personnel which builds and maintains the machines of the Fighter Command in ever-increasing numbers. The record counterstroke was delivered on Sunday, September 15, when the enemy lost 187 aircraft, a total not far short of 50 per cent. of the raiding force. That such a result was achieved with a loss of only 25 British machines, twelve of the pilots of which succeeded in landing by parachute, was not the least remarkable feature of the accomplishment. As the Prime Minister has pointed out, there is no reason to suppose that the enemy has yet put forth the full effort of which his air forces are capable ; but the same is true of the Royal Air Force, and as time goes on and the productive capacity of the Empire and of the United States comes more effectively into play, while that of the enemy becomes progressively more severely stressed, any advantage of numbers now enjoyed by the *Luftwaffe* must become less and less a potentially decisive factor in determining the course of the war.

It has been announced that the casualties during the course of the present series of intensive raids amount, since the beginning of September, to some 2,000 killed and 8,000 injured, of whom all but a very small proportion are civilians. In all the circumstances, this can only be regarded as a very inadequate result by comparison with the efforts involved in the achievement. The damage to property has been widespread and, by the standards of centuries of peace, relatively costly ; but it is still perfectly true that, from a strictly military standpoint, the raids have been remarkably unproductive in this respect also. Many famous buildings have been hit—hospitals, museums, the Law Courts, Somerset House, and several of the historic City churches have suffered more or less extensively in this way ; but these "incidents," as the official A.R.P. terminology quite rightly calls them, do not affect the ability of the nation to continue to prosecute the war with vigour, and only serve to stiffen the public determination to exorcise from among the civilised nations the evil influences which can deliberately impose such barbarous methods of war upon peoples whose only wish is to live peacefully with their neighbours.

The disruption of communications and public-utility services, on the other hand, may be accepted as a legitimate military purpose, and in this respect, it must be admitted, some local and largely temporary success has been achieved ; indeed, the very complexity of London's transport system made some measure of success almost inevitable. Here again, however, such expectations as Field-Marshal Göering may have entertained regarding the dislocation that his operations effect must have been largely nullified by the course of events, aided not a little by the native adaptability of the Londoner to untoward circumstances. The emergency has unified the various services, in a matter of days, to an extent never achieved by mere co-ordinating legislation ; and it may even prove to be an ultimate blessing, however well disguised for the moment, by demonstrating the practicability of closer inter-working of the various means of transport and inter-availability of tickets, and, in particular, emphasising the advantage of making a better use of the River Thames, as a highway The rapid institution of the "water 'bus" service, so long and ardently advocated by the late Sir Samuel Instone and others, is a move on which those responsible are to be congratulated. It is to be hoped that the experience gained will justify the retention of some such service after the war.

While the general public can be said to have risen nobly to the present unprecedented conditions, there is very obvious room for some improvement in the matter of air-raid warnings and the action to be taken on receipt of them. A statement issued so long ago as September 10 by Mr. Winston Churchill encouraged the hope that the general adoption was imminent of the revised scheme to enable work to continue after the warning syren had sounded, except in those areas directly menaced by the presence overhead of enemy aircraft. Consultations between the Government and representatives of the Trade Union Congress, the British Employers' Federation, the Federation of British Industries and the Association of British Chambers of Commerce resulted in the evolution of the modified scheme, now in operation in many industrial establishments, under which the syren is regarded merely as an "Alert" signal, the actual "Take Cover" warning being given in each establishment by a watcher posted on the roof. It was agreed, as an essential feature of the scheme, that the fact that work continued after the syren sounded would not prejudice any rights to compensation for personal injury under the Government scheme, or under any known life-insurance policy covering war risks, nor would it affect the position of employers under the Personal Injuries (Emergency Provisions) Act.

It follows, necessarily, that the details of the

application of a relatively flexible scheme of this kind must be left to the individual firm to arrange in the light of their particular circumstances. Shelters are not all equally accessible; the size and design of a building, and the number of persons employed in it, must affect the margin of time necessary in taking cover; and in some works, situated near obvious targets, it may be advisable for the previous practice to be retained, everyone taking cover immediately the syren is heard. In many cases, it is suggested, good cover may be provided in the immediate neighbourhood of the work, so that it will not be necessary to organise a general exodus to shelters constructed elsewhere. The basic principles of the scheme seemed so obviously sound, and were already being applied in so many establishments, that it was disappointing to be informed by the Prime Minister, in his statement to the House of Commons on September 17, that the promulgation of new rules to clarify the position had been temporarily deferred. The need for some definite ruling is all the more apparent since there appears to be no uniformity of practice at present among the Government Departments themselves.

In some respects, the forecasts of the nature and extent of air-raid damage have proved to be more alarming than the facts. Suggestions that, where a large bomb might explode in ordinary residential districts, it might be necessary to evacuate all property within a radius of half a mile, until the premises could be certified as safe for occupation, have not been justified by the facts; indeed, there have been a number of instances of houses in the centre of terraces being entirely demolished without involving what marine underwriters would describe as "constructive total loss" of those immediately adjoining. The forecasts of danger due to flying glass, on the other hand, cannot be said to have exaggerated this risk. As was expected, the effect of bomb explosions in closely built-up districts has proved quite impossible of accurate prediction, but where there has been any extensive shattering of windows, the fine pulverisation of the fragments, and the way in which they have penetrated closed cupboards and drawers of furniture, textile materials and even between the leaves of closed books, has emphasised the desirability of pressing forward all possible research into the provision of suitable glass substitutes. Possibly because of this pulverisation, however, the anticipated danger that fragments from broken windows, projected into roadways, might immobilise fire-fighting and other services by cutting the tyres of vehicles, has not proved to be a serious risk.

The Research and Experiments Department of the Ministry of Home Security has been engaged for some time in investigating both the possibility of minimising breakage of glass, and the availability of suitable substitute materials with which to replace windows and roof lights, in particular. The replacement of internal partitions and door lights, obviously, is of less importance; indeed, it may be expected that many of these will be drawn upon as a convenient source of supply for the repair of windows required for weather protection. The various treatments designed to prevent scattering of fragments from broken windows have proved to be reasonably effective, but they do not obviate breakage, and the problem of replacement still remains. Wire braces, it has been found, are of little real use, and may be definitely disadvantageous in that they tend to instil a false sense of security. The possibility of increasing the resistance of large sheets of plate glass is still under examination, but, so far, it is stated, the research does not indicate anything more positive than the desirability of providing a flexible setting for the glass, with which to take the first shock of the blast. The study is one which should have a definite peace-time value, even though the eventual solution—for there are likely to be several of approximately equal efficiency—may not be immediately applicable on any extended scale. Unless aerial warfare can be effectually banned in the future, it may well be that post-war building legislation may require the use of some form of safety glass, at least in windows facing public thoroughfares; in which case it is not improbable that private enterprise may make its adoption even more general.

LIGHTNING AND THE TRANSMISSION LINE.

THERE are good reasons why discussion of the weather, both wholesale and in detail, should be under an embargo until peace is declared, but these need not prevent the engineer from discussing some of the more scientific of its aspects, as they may affect the work that he is doing; for instance, how the increase in the mileage of electrical transmission lines working at very high pressures has introduced problems connected with lightning effects. Lightning, like the wind, moves "as it listeth," although, in spite of the well-worn joke about the English summer consisting of two fine days and a thunderstorm, in general it causes little inconvenience to those who have charge of overhead transmission lines in this country. So little troublesome is it, in fact, that for economic reasons lightning arresters are frequently conspicuous by their absence on such installations, the argument being that it is not worth while to insure against an event which happens so seldom as does a lightning stroke.

This point of view, however, has been compulsorily modified to some extent with the advent of the national transmission network. This network, which operates at a pressure twice as great as that of any other system in the country, offers a correspondingly greater inducement to lightning phenomena; although, therefore, initially general lightning protection for the grid lines was not provided, it was soon found to be advisable, especially in certain areas, and the Central Electricity Board with their usual energy undertook an investigation into the subject in co-operation with the British Electrical and Allied Industries Research Association. In their twelfth report, for the year 1938, it was mentioned that progress had been made with field work with the object of determining the characteristics of lightning, and that cognate investigations were being made into the best means of reducing the stresses caused by it in inductive apparatus, such as transformers and reactors. In the report for the following year it was mentioned that the field work had been completed by measurements on the new 132-kV line between Leicester and Corby; these measurements in particular determined the electrical characteristics of overhead lines on which double earth wires were used. Since lightning is much more troublesome in some other countries than in the British Isles, complementary investigations were started in Nigeria to determine its characteristics. The properties of the available types of lightning arresters were also ascertained, and, as a result, this type of apparatus was installed on the lines at Barking, a district which is particularly liable to be affected by storms. It is clear, therefore, that while, through no fault of our own, we were late in the field, steps are being taken to make up the leeway where that course has proved to be necessary.

In the United States, on the other hand, the problem has long been one which has demanded the closest attention. In the first place, lightning storms are much more prevalent than in this country; and, secondly, the mileage of overhead lines working at very high pressures is also greater. Lightning phenomena are also closely bound up with the question of stability, one of the difficulties in connection with which is the calculation of the performance of the system. To do this analytically is always tedious and sometimes impossible. An ingenious instrument known as the network analyser has been devised, therefore, the essential feature of which is that the system is set up in miniature and operated as it would be in practice, faults and all. In this way it is possible to obtain the results desired without complicated calculations, and it is actually in use on more than 200 systems in the United States. During the past ten years, too, its scope has been broadened and among the new and interesting problems on which it has been employed is the application of the De-ion protector to transmission lines. This protector is a device which is connected in parallel with the line insulation. When lightning strikes the line, the surge current flows through the protector, which then practically short-circuits the line, instead of through the insulation; but to perform its function correctly, it must become an insulator again before the circuit breakers are tripped.

According to Mr. A. C. Monteith, writing in *Electrical Engineering* of June, 1940, the employment of this protector has enabled lines that are practically lightning-proof to be designed and has provided a means of rehabilitating existing lines which are particularly vulnerable to the effects of lightning. This general statement raises two questions: What do we know about the nature of lightning and how can we protect lines and equipment against it? These questions have long been under examination both in the field and in the laboratory in order to see if a large number of faults which occur could be eliminated. The result is that it is not now so much a matter of building a lightning-proof line but of discovering the best way of building such a line at the lowest possible cost. To do this, in Mr. Monteith's view, it is necessary to acquire more information regarding the exact wave shape of the front and tail of the lightning stroke, and its magnitude and duration. Steps have already been taken in this direction by Schonland in South Africa, who has evolved a theory of lightning discharges, while McEachron, in the United States, has secured a great deal of data on the magnitude of surges. Wagner, too, has devised an instrument which enables a complete graph of the magnitude and duration of the lightning discharges to be secured.

To indicate the importance of this it may be pointed out that burns on lightning-arrester gaps could only be reproduced in the laboratory by using long low-current surges with magnitudes of the order of 2,000 to 4,000 amperes and durations up to 3,000 micro-seconds. The fulchronograph, on the other hand, enables a complete story of the magnitude and duration to be secured by measuring the current in the strokes or in that part of the transmission lines through which a current flows, associated in some manner with the lightning current. Two types of this instrument have been developed: one, the high-speed type, measures total intervals of time of the order of one cycle; the other, or slow-speed instrument, measures current variations of a duration of about one second. These two instruments are connected in the circuit and, therefore, can be used to measure the current without opening the circuit. Their operation is based on the principle of storing the current indication in the form of resonant magnetism, which is later measured at leisure. They are, therefore, similar in principle to the surge-crest ammeter.

Using this instrument, it has been found that currents of the order of 100,000 to 200,000 amperes can exist, that surges of low magnitude are more probable than those of high magnitude, that long-duration surges of low magnitude can exist, and that there can be one or more repeated strokes in the space of a few cycles. In a more general way, the results of the investigations in which it has been used have enabled economical lightning-proof lines to be built by the proper use of earth wires. The design of the lightning arresters themselves has also been affected; for instance, the possibility that they will have to discharge currents of high magnitude having been recognised, they have been constructed both to be capable of carrying these currents and to protect the apparatus. Their characteristics have also been altered to enable them to discharge surges of long duration.

Interesting as this work is, however, it seems probable that economics will be the principal factor in determining whether the apparatus described shall be adopted. On the Detroit Edison Company's 24-kV system, for instance, which consists of 1,000 miles of overhead lines, there has been an average of 28·5 interruptions of supply per 100 miles of line per year during the past five years; only one of these, moreover, caused an interruption exceeding 5 minutes in duration. Indeed, trees, wind, failure of equipment and public interference were all more troublesome. Though it is true that, as the operating pressure is raised, the risk of failures due to lightning will increase, it would seem that, in this country, there are many situations where any great expenditure on the necessary protective equipment would hardly be justified.

NOTES.

COMPETITION IN ELECTRICAL EXPORTS.

THE extreme pressure which has been brought to bear upon manufacturing industry to accelerate the production of the equipment necessary to maintain the war effort has rather tended to obscure the almost equal necessity of maintaining British export trade. The importance of this, however, has not been altogether overlooked and it is satisfactory to learn that considerable progress has been made with the formation of combinations of manufacturers and tra ers, conveniently known as export groups, for this purpose. In the electrical industry, for instance, the groups at work represent over 90 per cent. of the country's electrical export trade in normal times, and while exports in June were naturally appreciably lower than in May, they were still higher than those for June, 1938. For the first six months of the year the aggregate exports of electrical goods and apparatus was 10 per cent. higher than in 1938 and 18 per cent. higher than in 1939. This position will probably be improved by the recent relaxation of control on export and the limitation of the home consumption, both of machinery and consumers' goods. It will also be assisted by the efforts of the Board of Trade to secure materials for manufacture for export. How important such efforts are will be made clear by exhibiting the other side of the picture. There seems no doubt that American competition for overseas markets is becoming more intensive and that, seeing that their position is one " of greater freedom and less responsibility," there is every chance that it may be progressively serious. In fact, American electrical export figures for June showed a substantial increase in value over the corresponding months for last year. It seems clear, indeed, that the Latin-American markets are turning to the United States for much of the equipment they formerly obtained from Europe. A great deal of that equipment was, admittedly, of German origin and, thanks to the Navy, is no longer available. This does not mean, however, that Britain is thus provided with a clear field; rather does it show the necessity of using every effort to establish such a goodwill in the available market as will withstand the intensive competition to be expected when peace is restored.

FACTORY LIGHTING.

The current issue of the *I.M.E.A. Journal* contains an account by Mr. C. W. Sully of what has been done during the past few months to secure adequate artificial lighting in factories within the limits imposed by the black-out. In February last, a letter was addressed by a Joint Committee of the Incorporated Municipal Electrical Association and the Electric Lamp Manufacturers' Association to H.M. Chief Inspector of Factories pointing out that war conditions made it necessary to work longer hours under artificial lighting. It was suggested, therefore, that the illumination levels recommended to executives for specific tasks in industry should be based upon the upper part of the appropriate range of the Illuminating Engineering Society's code. It was also suggested that the proposals of the Fourth Report of the Departmental Committee on Lighting in Factories should be made obligatory. Since then, as has already been noted in ENGINEERING, the Fifth Report of the Departmental Committee has been published. This proposes that an illumination of 6 foot-candles should be made compulsory at a minimum height of 3 ft. from the floor. The Admiralty, the Ministry of Supply and the Ministry of Aircraft Production have issued instructions to key factories asking them to report the name of the firm from whom they are obtaining advice and estimates for bringing their lighting up to the required standards, or to submit their requirements to a Joint Lighting Committee, in order that a firm may be nominated to deal with an inquiry. This Joint Lighting Committee contains representatives of the appropriate electrical associations and is presided over by Sir Duncan Wilson, the secretariat being provided by the Lighting Service Bureau of the Electric Lamp Manufacturers' Association. At its first meeting, which took place some weeks ago, this Committee, at the request of the Ministry of Supply, set up sub-committees of reputable lighting firms to establish " an equitable rota for operation by the secretariat," and to agree on reasonable standardisation of lighting practice, in order to ensure urgent attention being given to the requirements of all key factories. Both sub-committees are now operating on behalf of the Service Departments, and inquiries addressed to the secretariat are passed on to a competent firm, who at once arrange for an illuminating engineer to visit the factory and deal with the inquiry at the request of the Joint Lighting Committee. More recently, the Ministry of Labour has indicated its desire to make use of the Committee if and when the recommendations of the Departmental Committee on Factory Lighting are adopted by the Government.

PASSENGER ROAD TRANSPORT IN GLASGOW.

According to the report of the general manager of the Glasgow Corporation Transport Department for the year ended May 31, 1940, experiments are in progress with a view to saving the consumption of fuel oil on the 'buses. Producer gas and compressed town's gas are being tried as alternatives, while the fuel oil ration is being supplemented by creosote obtained from the Corporation's gas works. In spite of the war, considerable development work has also taken place. The construction of the central 'bus overhaul shops adjoining the garage at Larkfield has been practically completed and the necessary plant is now in course of installation. Additional garage accommodation has been provided at Elderslie and Knightswood, while at the latter place a washing plant for dealing with the exteriors of the vehicles has been constructed. This is operating satisfactorily and has resulted in a considerable saving in cost. All the older petrol-engined 'buses have been disposed of and the entire fleet of 578 vehicles, with the proviso already stated, is being operated on Diesel fuel oil. The Corporation, of course, operates one of the most extensive tramway systems in the Kingdom and it is therefore interesting to note that four experimental cars were built during the year, which indicates that this form of traction is, perhaps, not so obsolete as it is sometimes alleged to be. To meet the increased load at Darnley, a new sub-station containing 1,000 kW of mercury-arc rectifying plant has been built at Spiersbridge. This will ultimately displace the 300-kW sub-station at Barrhead, high-tension electrical energy being obtained from the Department's own generating station at Pinkston instead of from the system of the Clyde Valley Electrical Power Company. For the same reason, the Whitevale sub-station has been increased in capacity from 5,000 to 9,000 kW.

THE AMERICAN DESTROYERS NAMED.

On Tuesday, the First Lord of the Admiralty made an interesting announcement regarding the names of the destroyers which have been handed over under the recent Anglo-American agreement. This question has, perhaps, assumed an interest out of proportion to its real importance, but the solution that has been found will, we think, be generally commended in both countries. It had been wisely arranged that the original names should not be retained; and the choice of alternatives has been carefully considered, including the suggestion that they should be named after the co-operating colonies. Actually, the names that have been chosen for the first flotilla are: Churchill, Caldwell, Cameron, Castleton, Chelsea, Chesterfield, Clare and Campbeltown. As regards the leader, it is not the name of the Prime Minister which is perpetuated, worthy as he is of that honour, but of a town, the name of which is common to the United Kingdom and to the United States. That system has more obviously been followed in the case of the other ships. Actually, there are Churchills in Oxford, Somerset and Worcester, as well as in Devon, from the last of which the Marlborough Churchills originated. The American counterpart is in Nevada. Mr. Alexander added that names on a similar basis for the other American destroyers would shortly be given and would include a few names common to the West Indies as well.

MARKETS IN BRAZIL.

As in the case of most South American countries, the economic development of Brazil over many years has been due, in major part, to the pioneer efforts of British financiers and engineers. The total amount of British capital invested in Brazil is estimated at about 261,000,000*l.* sterling, which, among South American countries, is second only to the amount invested in Argentina. Nevertheless, for some years prior to the present European War, Germany made remarkable penetration into the import markets in Brazil—as in Chile, Peru and other countries in South America—through the operation of " compensation " business based upon the depreciated *Aski* mark. This is borne out by the fact that, between the years 1932 and 1938, the percentage of Brazil's total imports represented by German goods rose from 9 per cent. to 25 per cent., whereas, over the same period, Brazil's imports of British goods fell from 19 per cent. to 10 per cent. Due to the extension of German-occupied territory in Europe, however, and the application of the British naval blockade thereto, Brazil's trade has ceased with Germany and practically the whole of Europe, except Britain, and this has changed the whole outlook for British imports into Brazil. Britain and the United States should now be in a position to capture the trade formerly enjoyed by Germany, and they are making every effort so to do.

The fourth largest country in the world, Brazil is the largest of the South American republics, and touches the boundaries of all except Ecuador and Chile. It has an area of 3,300,000 sq. miles, which is three-sevenths of the whole of the South American sub-continent. Its seaboard is 4,060 miles. Brazil is larger than Australia, and approximately four-fifths the size of Europe. It extends 2,629 miles from Cape Orange to the River Chuy, and 2,600 miles from Olinda westwards to the Peruvian boundary. The two river basins of the Amazon and La Plata comprise about three-fifths of the total area. Both are heavily wooded, and the Amazon basin is annually in flood over a wide extent. The huge plateau forming the country's main physical feature is a tableland from 1,000 ft. to 3,000 ft. above sea-level, and is traversed by two great mountain chains. There are 30,070 miles of navigable rivers in Brazil, over 17,130 miles of which there are regular services of vessels. Brazil may be divided into three zones. The first zone occupies the equatorial region and extends to the tenth degree of south latitude; the second reaches from 10 deg. south to the tropic of Capricorn; the third zone lies between the tropic of Capricorn and parallel 33 deg. 45 min., the southern limit of the republic. The climate of Southern Brazil, including Rio de Janeiro, is sub-tropical. Northern Brazil is inclined to be enervating, although a more bracing climate prevails on the tablelands.

Twenty federated states form the republic of Brazil, and it is important to note that states and municipalities are not allowed to contract foreign loans without the permission of the Federal Council. Although Rio de Janeiro is the federal capital, the chief producing and manufacturing zone is the State of São Paulo. The total population of Brazil, as at December 31, 1938, was estimated at 44,115,825 persons, compared with the previous census total, in 1920, of 30,633,605 persons. The population of the State of São Paulo, at December 31, 1939, was estimated at 7,305,407 inhabitants, compared with the 1938 estimate of 7,131,486 and the actual census figure in 1920 of 4,592,188. In the city of São Paulo alone, the estimated population at the end of December last was 1,322,643 inhabitants, an increase of 53,749 on the estimated figure for 1938; the 1920 census gave the population as only 579,033 persons.

The figures of Brazil's oversea trade during several years past are given in Table I, page 234. These show that, during the years following the last Great War, Brazil participated in the export boom enjoyed by most primary producing countries. In the following crisis years of 1929 onwards, however, when the world experienced a slump in commodity prices, Brazil's exports fell sharply, and, in 1939, aggregated in value only about one-quarter of those in 1919. The table shows the adverse effect upon

imports of the loss of purchasing power due to reduced exports, as well as the attenuated trade balance. This, of course, is a vital matter in the case of a debtor country such as Brazil, and fully explains the difficulties of maintaining the service of the foreign bonds. Actually, the service of Brazilian loans has been irregular over the past forty years, various schemes for funding interest and suspending capital amortisation having been announced. In 1934, the Aranha Plan was introduced, by which, over a period of four years, interest and amortisation services were to be effected on a reduced scale averaging about 8,000,000*l.* a year, compared with the full annual service of approximately 23,000,000*l.* This plan was not fully carried out, and the debt service was in complete default from November, 1937, to March, 1940, when a new four-year plan based upon the Aranha Plan was formulated, interest and amortisation services being further scaled down to an average of 4,200,000*l.* each year. In effect, this means that the annual rate of interest on the whole of the foreign debt of Brazil is reduced to little more than 1 per cent. With the recent steep fall in Brazil's exports owing to the loss of European markets, even the present exiguous payments upon Brazil's foreign debt hardly look like continuing after the current year.

TABLE I.—*Brazil: Imports and Exports.*

Year.	Value in £ (Gold).		
	Imports.	Exports.	Trade Balance.
1913	67,166,000	65,451,000	— 1,715,000
1917	44,510,000	63,031,000	+ 18,521,000
1919	78,177,000	130,085,000	+ 51,908,000
1920	125,005,000	107,521,000	— 17,484,000
1925	84,443,000	102,875,000	+ 18,432,000
1928	90,669,000	97,426,000	+ 6,757,000
1929	86,653,000	94,831,000	+ 8,178,000
1930	53,619,000	65,746,000	+ 12,127,000
1931	28,756,000	49,544,000	+ 20,788,000
1932	21,744,000	36,630,000	+ 14,886,000
1935	27,431,000	33,012,000	+ 5,581,000
1936	30,066,000	39,069,000	+ 9,003,000
1937	40,608,000	42,530,000	+ 1,922,000
1938	35,916,000	35,945,000	+ 29,000
1939	31,801,000	37,298,000	+ 5,497,000

Taking the long view of Brazil's potentialities, however, much encouragement derives from the remarkable variety of natural resources of the country. Due to the immense area and the varieties of climate, etc., practically all farming products can be grown with little effort; the country is rich in mineral resources, much of which is undeveloped; and the only limits imposed upon further great development arise from labour and transport deficiencies. As is well known, Brazil is the world's chief producer of coffee, and, due to difficulties caused by over production (which will be referred to later), much attention has been given, with very favourable results, to the production of other farming products for export, extraordinary success, for example, having attended the efforts to increase the production of cotton. Thus, while the proportion of coffee to Brazil's total exports fell between 1933 and 1939 from 73 per cent. to 40 per cent., the ratio represented by cotton shipments increased from 1 per cent. to over 20 per cent. However, as will be seen from the statistics of the principal exports from Brazil, given in Table II, herewith, coffee still leads in Brazil's export account.

Among the multitudinous products of the country, in addition to coffee and cotton, may be mentioned cocoa (of which Brazil is the second largest world producer), tobacco, rubber, rice and sugar; while the forest area, computed at 1,000 million acres, furnishes timber of unexcelled variety, ranging from the very hardest to the lightest kinds. Further, the Amazon Valley constitutes, in the extent and variety of its oil-bearing plants, probably the largest source of vegetable oils in the world. Fruit cultivation is an important industry, wheat, maize, beans, etc., are grown extensively, and the cattle-raising and meat-exporting industries are of very considerable importance. Among mineral riches, gold is produced (mainly in Minas Geraes), as are also manganese, bauxite, asbestos, barytes, chromium, copper, mica, molybdenum, nickel, platinum, silver, lead, tin and tungsten, precious stones and petroleum. A new Mining Code was decreed in January, 1940, which determines the conditions under which mining in Brazil is permitted, the chief points being that the right to prospect and work mineral bearings would be conceded only to Brazilian persons and entities; while mining concerns would enjoy sundry benefits, such as exemption from import duties on machinery, etc., as well as minimum tariff rates on Federal railways, shipping and port services.

There are large reserves of iron ore, chiefly of magnetite and hematite, computed at over 20 per cent. of the available world supply, although transport difficulties are a retarding feature. The deposits occur chiefly in Minas Geraes and southward. The average content of metallic iron is estimated at 60 per cent. or more, with a low percentage of phosphorus. Progressive expansion has been recorded during recent years in the production of pig iron, the output in 1939 having reached 160,016 metric tons (of which 143,603 tons came from the State of Minas Geraes), compared with 58,560 tons in 1934. The present annual production of steel is around 111,000 tons, and of sheet iron about 97,000 tons.

TABLE II.—PRINCIPAL EXPORTS FROM BRAZIL.

Exports.	Volume, Metric Tons.		Value, £'s (Gold).	
	1936.	1939.	1936.	1939.
Coffee	14,185,506 bags	16,498,525 bags	17,785,000	14,892,000
Cotton	200,313	323,539	7,455,000	7,645,000
Hides and skins	58,155	57,471	1,667,000	1,633,000
Cocoa	121,721	132,153	2,077,000	1,494,000
Meat	74,149	83,210	991,000	1,464,000
Carnauba wax	8,774	10,001	774,000	802,000
Oranges	3,216,712 boxes	5,631,943 boxes	605,000	792,000

TABLE III.—PRINCIPAL IMPORTS INTO BRAZIL.

Imports.	Volume, Metric Tons.		Value, £'s (Gold).	
	1936.	1939.	1936.	1939.
Machinery, tools, etc.	61,682	62,930	5,144,000	6,307,000
Iron and steel manufactures	225,314	237,353	2,541,000	2,830,000
Wheat	919,860	966,831	4,347,000	2,263,000
Chemical products	120,238	156,101	1,433,000	1,846,000
Motor-cars, lorries and chassis ..	18,971 units	21,748 units	1,401,000	1,827,000
Other vehicles and accessories ..	28,602	22,510	979,000	1,505,000
Coal and coke	1,431,175	1,382,471	1,180,000	1,484,000
Petrol	325,402	370,087	1,097,000	1,071,000

In accordance with the present Government's plans for industrial development, President Vargas announced, in January, 1940, plans for the installation of a large-scale national iron and steel industry. In February it was reported that negotiations which had been proceeding for the investment of 35,000,000 (United States) dols. by an important North American concern for inaugurating this Brazilian industry had been suspended, due partly to the difficulty of obtaining adequate skilled labour. Nevertheless, the Brazilian Government stated that it intended to continue with the project, and, in March, 1940, a Government decree established the Executive Board for the National Siderurgical Plan, the functions of which were to include investigations regarding the construction of a plant for the production of rails, sheets and shaped iron and steel, in connection with which investigations were also to be undertaken regarding measures required to improve and distribute the types of national coal suitable to the industry. At the first meeting, in March, 1940, of the Executive Board, however, it was stated that the construction and installation of the relative iron and steel factories would take at least five years to complete. In April, the President of the Republic announced a plan for utilising Brazilian coal to produce coke for the national iron and steel industries. Brazil's coal reserves are estimated at 5,000 million tons, the annual production amounting to 850,000 tons.

The manufacturing industries of Brazil have shown remarkable expansion over recent years, so that already the bulk of the home demand for most articles, except engineering products, is supplied by the national factories. The national production of manufactured articles to-day is valued at 9,000,000 contos of reis (108,000,000*l.* sterling), while the number of industrial concerns has risen since 1920 from 13,300 to 30,000. Extraordinary progress in manufacturing industries has been made, particularly in the State of São Paulo, under the protection of heavy customs tariffs and by the utilisation of electric power. In this State alone, the number of factories engaged in the preparation of metals and the manufacture of machinery is 1,261, employing over 27,000 operatives. The chief manufacturing industry, however, is textile spinning and weaving.

Industrial development is very greatly helped by unlimited water power. Brazil's hydraulic resources are estimated at 19,519,000 h.p., distributed mainly in the States of Minas Geraes (5,828,000 h.p.); Matto Grosso (2,202,000 h.p.); Pará (1,875,000 h.p.); Bahia (1,223,000 h.p.); Goyaz (1,110,000 h.p.); São Paulo (2,602,000 h.p.); and Parana (2,593,000 h.p.). The total number of electricity-generating concerns which existed in the country at the end of 1938 was 1,149, distributed mainly in the following States:—Minas Geraes, 262; Rio Grande do Sul, 133; São Paulo, 110; Pernambuco, 103; Espirito Santo, 69; and Bahia, 60.

Inadequate transport continues to be Brazil's main problem, especially by impeding the carriage of products from the interior to the coast, but the present Government is pursuing a comprehensive policy of development, embracing railways, roads and air services. Coupled with the industrial development, therefore, it is not surprising that, with the heavy purchases of productive machinery, rail equipment, etc., these lines should figure prominently among imports into Brazil, as shown in Table III, herewith. The Brazilian Government decreed, in January, 1939, a five-year development plan involving the outlay of about 37,500,000*l.* sterling, a large part of which was to be spent on transport and public works as well as on the national siderurgical industry. Road construction has been pressed on with new energy, notably in the State of São Paulo, which also explains the expansion in imports of automotive vehicles.

The present constitution provides for the progressive nationalisation of various forms of economic activity, and the Government has, so far, taken certain steps in this direction in regard to some railways and port works, insurance companies, and petroleum refineries. The policy of the Government in this matter was indicated a few months ago in a speech by the President, in which he stressed the importance of attracting foreign capital which is employed for converting national raw materials into finished products, as opposed to that used in the production of raw materials that are exported for manufacture abroad into materials which may subsequently be resold to Brazil. Important railway developments are being undertaken, including the electrification of the Central of Brazil Railway and of the Sorocabana Railway, the contract for the latter having been awarded recently to a North American consortium. Moreover, under credits granted by the Export-Import Bank of Washington, considerable quantities of railway equipment have been sold to Brazil by the United States.

(*To be continued.*)

SCIENTIFIC AND INDUSTRIAL RESEARCH IN AUSTRALIA.

IN the Commonwealth of Australia research on a national scale is supervised by a Council for Scientific and Industrial Research, which was established in 1926 by the reorganisation of a previously existing body known as the Institute of Science and Industry. Within the present organisation are included main committees representing each State of the Commonwealth (except Northern Territory), together with specialised technical committees to direct investigations in each of the main divisions in which research is proceeding. The actual work is conducted at a large number of laboratories and field stations, most of which are, naturally, situated in the least thinly-populated districts of Victoria and New South Wales, while the remainder are adequately distributed to deal with problems arising out of local conditions. In this connection, the Australian universities have played an important part by inaugurating studies associated with the industries by which they are surrounded and supported, and subsequently by co-operating in programmes of research undertaken jointly with the State. The promising character of this organisation is fully confirmed by the Report* of the Council for the year 1938-39, which contains evidence of substantial technical progress and development along new lines of investigation, backed by an annual expenditure of close on 275,000*l.*, of which more than a quarter has been contributed by commercial bodies and similar sources other than the Commonwealth Treasury.

Since the primary industries of Australia are predominantly agricultural and pastoral at present, the technical part of the report is of interest rather to botanists and biologists than to engineers. It is instructive, none the less, to remark how large a proportion of such work is devoted to the study and control of pests and diseases that attack animals and vegetation. Similarly, the control of weeds by insects, cultural methods and poisons, demands a good deal of attention, and needs to be carried on in conjunction with studies of the most suitable plants for semi-arid land, monsoonal country, and districts where soil must be retained against erosion by soil-binding vegetation. Also noteworthy is the fairly recent introduction of research programmes to deal with problems of management, as affecting the welfare and products of sheep and cattle, and the economics of methods intended to improve agricultural land. As part of the large questions arising in Australia under this head, research stations are associated with the irrigation areas of the Murray and Murrambidgee Rivers. The horticultural aspects of irrigation applied to the grapes and citrus fruits grown in these two districts, respectively, figure prominently among the experimental investigations in progress, while both stations are concerned with general questions of water distribution, soil erosion and drainage, which should be of great value when the time comes for other irrigation areas to be developed.

An important branch of research, devoted to forest products, offers more scope for engineering applications and notable expansion has recently taken place in the direction of wood manufacturing processes and the standardised grading of timber for purposes including veneers and plywoods. One result of the work of the year under review is the publication of a Timber Handbook which provides tabulated data on the strength properties of Australian timbers in suitable form for designers. New work has also led to valuable salvage of timber damaged by forest fires, and to the profitable commercial use of thousands of tons of other waste wood. Investigations are also in progress to improve woodworking machinery and to extend the pulping and paper-making industries of the Commonwealth.

The preservation and storage of foodstuffs are among the long standing subjects of scientific research in Australia, but they are still being actively pursued and close attention is being given to new developments in gas storage. The processing and canning of fruit juices figure prominently among current work, associated with which is a comprehensive effort to discover a corrosion-resistant, non-tainting lacquer suitable for internal application to tinplate containers. Fish is among the foodstuffs subject to storage research, a notable new departure here being a scientific endeavour to smoke such Australian fish as may be found suited to this form of preservation, and thereby to enhance the value of an industry to which the other fisheries investigations sponsored by the Council are already contributing effectively.

The branches of Australian research of greatest interest to engineers were no more than very promising projects when the 13th annual report was written, though the outbreak of war has, no doubt, expedited progress with them in some directions. They include the establishment of an Australian National Standards Laboratory at Sydney, an Aeronautical and Engine Testing Research Laboratory at Fisherman's Bend, near Melbourne, a chemical laboratory for secondary industrial research, also at Fisherman's Bend, and an information service located at the Council's headquarters. The Standards Laboratory will comprise a Metrology Section, having custody of the national standards of mass and length and maintaining the derived standards of volume, density and pressure ; an Electrotechnology Section, responsible for derived electrical standards ; and a Physics Section, in charge of the Australian legal electrical standards, and the standards of heat, light and sound. The Aeronautical Laboratory is organised in four divisions, to deal, respectively, with aerodynamics, structures and materials, engines and fuels, and instruments and electrical equipment. At present, only one wind tunnel is projected, but it is to be a large one, made of welded steel, operated by a 500-h.p. fan-motor and having a working section 7 ft. high by 9 ft. wide. The final design is being based on the results of tests upon a small-scale model in the University of Melbourne.

The establishment of these new laboratories is only a part, though a vital part, of the general movement for the dissemination of uniform, accurate measurement and reliable, unbiased technical data, throughout Australian industry. The same objects are already being served by the Council's information service, the need for which is abundantly evident from the inquiries received during the year covered by the report. The number and variety of such inquiries are eloquent testimony both to the growing importance of mechanical and manufacturing industries in Australia and to the respect accorded to scientific research as an aid to their successful development. Upon such a foundation the industries which the Commonwealth now regards as secondary may confidently be expected to make rapid progress towards prosperity.

* Thirteenth Annual Report of the Council for Scientific and Industrial Research, for the Year 1938-39. Published by the Government of the Commonwealth of Australia. [Price 4*s.* 6*d.*]

EXPORTS OF SCRAP FROM THE UNITED STATES.—According to the American journal, *The Iron Age*, 317,202 tons of iron and steel scrap were exported from United States ports during June.

BRITISH TRADE WITH SOUTH AMERICA.—It is stated in *The Board of Trade Journal* that two representatives of the United Kingdom Commercial Corporation are to sail shortly for Argentina with the object of setting up an organisation to facilitate trade between the United Kingdom and South-America. To supplement the normal deliveries of British goods to South American markets, the President of the Board of Trade, acting on the recommendation of the Export Council, has authorised the Corporation to take the necessary steps to facilitate the holding, in South America, of adequate stocks of United Kingdom goods which South America requires. As rapidly as conditions permit, the United Kingdom Commercial Corporation will endeavour to create in other South American countries organisations similar to that to be set up in Argentina. The Corporation will not itself trade but will use existing trade channels and help in opening up new ones. About 1,000,000 tons of shipping is at present employed in trade between South America and the United Kingdom. It is believed that the arrangements now being made will lead to considerable trade expansion.

THE LATE SIR HAROLD CARPENTER, F.R.S.

THE news of the death of Sir H. C. Harold Carpenter, M.A., D.Sc., F.R.S., at Swansea, on September 14, will be received with regret by technical and scientific men in all parts of the world. Sir Harold, who had been Professor of Metallurgy at the Royal School of Mines, Imperial College of Science and Technology, South Kensington, since 1914, was a scientific metallurgist of international repute. The second son of the late Mr. William Lant Carpenter, and a great-great-grandson of Henry Cort, who invented the puddling process for the manufacture of wrought iron and introduced the use of grooved rolls for metal rolling, Henry Cort Harold Carpenter was born on February 6, 1875. He was educated at St. Paul's School and at Eastbourne College, and subsequently went up to Oxford as a scholar of Merton College. In 1896, he obtained a First Class in Natural Science Honours Schools, and later secured the M.A. degree of the University of Oxford and the Ph.D. degree of the University of Leipzig. From 1898 until 1901 he was a research fellow and demonstrator at Owens College, Manchester. In 1901, he was one of the first to be appointed to the scientific staff of the newly-founded National Physical Laboratory, at Teddington, where, under Sir Richard Glazebrook, he was responsible for the establishment of the Chemical and Metallurgical Departments. Under his direction they quickly gained a high reputation for accurate work.

In 1906, when only 31 years of age, Carpenter became the first Professor of Metallurgy at Victoria University, Manchester, and, under his guidance the department became a flourishing teaching and research centre. These research activities were continued when he was appointed to the Chair of Metallurgy at the Royal School of Mines, Imperial College, in 1914, after spending some six months in the United States of America. Much of the research carried out by him, over a long period of years, was concerned with what is now termed physical metallurgy ; nevertheless, the results have been utilised in almost every branch of the metallurgical industries. His pioneer work, in connection with the determination of the freezing point of iron and the complete iron-carbon equilibrium diagram, carried out in collaboration with B. F. E. Keeling, was so fundamental in character as to form the basis for many other subsequent investigations. Moreover, his researches on high-speed cutting tools and other special steels ; on the causes of the growth of cast iron after repeated heatings ; his many contributions dealing with the constitution of alloys ; and his classical researches relating to the growth of single crystals in metals and the study of their properties, will long be remembered. In addition to his many contributions to scientific societies, Sir Harold was joint author, with Dr. J. M. Robertson, of an important two-volume work, entitled *Metals*, published last year. This deals with the metals and alloys used in industry and its aim is to give a reasoned and systematic account of the relations which exist between the treatment of materials and their properties and characteristics.

Carpenter, who was created a knight in 1929, was the recipient of numerous honours. He was elected a Fellow of the Royal Society in 1918 and was also an honorary associate of the Royal School of Mines, an honorary D.Sc. of the University of Wales, an honorary D.Met. of the University of Sheffield, and a corresponding member of the Swedish Royal Academy of Scientific and Industrial Research. In 1905, he gained the Andrew Carnegie Gold Medal for research, awarded by the Iron and Steel Institute, and, in 1927, delivered the James Forrest Lecture before the Institution of Civil Engineers. He was the Thomas Turner Gold Medallist in 1929, and, two years later, the Iron and Steel Institute awarded him the Bessemer Gold Medal in recognition of his distinguished services in the advancement of the science of metallurgy. In 1932, the Institution of Mining and Metallurgy awarded him its Gold Medal, "in recognition of his services in the advancement of metallurgical science and technology." In 1938, the American Institute of Mining and Metallurgical Engineers made him an honorary member. In March, 1939, he was the second recipient of the Platinum Medal of the Institute of Metals.

Sir Harold had been, for many years a member of the leading metallurgical institutions at home and abroad, and he successively occupied the presidential chair of our three principal national institutions in this sphere of activity. He was president of the Institute of Metals from 1918 to 1920, president of the Institution of Mining and Metallurgy from 1934 to 1935, and president of the Iron and Steel Institute from 1935 to 1937. He was honorary treasurer of the last-named Institute from 1926 until 1934. Sir Harold was formerly a member of the Advisory Council of the Department of Scientific and Industrial Research. At the time of his death, however, he was chairman of the Metallurgy Research Board of that Department.

THE LATE MR. P. V. McMAHON.

WE regret to record the death of Mr. P. V. McMahon, which occurred at Croydon on Saturday, September 14, at the age of seventy-two. He was one of the pioneers of electric traction in London and was particularly connected with the historic City and South London Railway when that line was operated as a separate system.

Peter Valentine McMahon was born at Dundalk on June 24, 1868, and was educated at the Christian Brothers Schools and St. Mary's College in that town. At the age of sixteen he was apprenticed to the Dundalk Iron Works and, on the completion of his articles three years later, migrated to London, where he was enrolled as a student at the Finsbury Technical College. Here he studied mechanical engineering under Perry and electrical engineering under Silvanus Thompson, obtaining the first prize in electrical technology as well as the certificate of the college. After leaving college, he was engaged for a short time on the construction of the electrical installation at Earls Court Exhibition, subsequently receiving the post of resident engineer to the electricity-supply station at Waterford, where he carried out a number of extensions and installed alternating-current generating plant. At this time, both civil and electrical engineers were taking a keen interest in the construction of the deep-level railway which was being carried out in London between King William-street in the city and Stockwell in the south-eastern suburbs. It was decided to operate this by electric traction, and the contract for the equipment was let to Messrs. Mather and Platt. McMahon joined this firm as resident engineer for the work and played his part both in the design and the installation of the equipment.

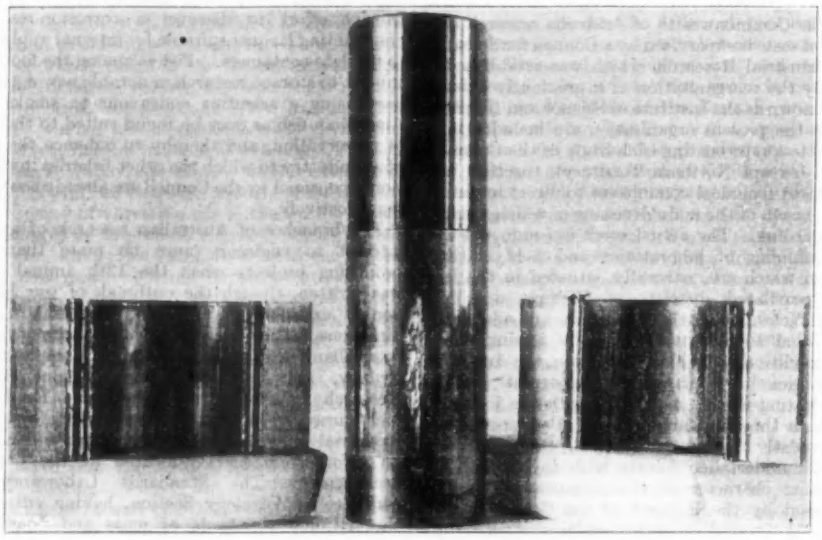
In 1896, on the retirement of Mr. (afterwards Sir Basil) Mott, McMahon was appointed engineer to the City and South London Railway, and acted as consultant when the line was extended from London Bridge to Moorgate in 1901, to Islington in 1901, and to Euston in 1907. On the amalgamation of the railway with other tube railways in London, in 1912, to form the London Underground system, he became superintendent of electric power, a position he also held, under the London Passenger Transport Board, until his retirement.

Mr. McMahon was elected a member of the Institution of Mechanical Engineers in 1904. He became an associate of the Institution of Electrical Engineers in 1889, and was transferred to the class of member in 1895. He had served for a period on the Council and, in 1899, was awarded the Institution Premium for a paper on the "Design of Electric Locomotives." He also received, in 1903, the Willans Premium for a paper on the "Three-Wire System as Applied to Electric Traction." At an earlier date, he conducted a research into the behaviour of electromagnetic devices, especially solenoids with cores of different shapes and sizes, the results of which were published in *The Electrician* under the title of "Notes on Some Experiments on Electromagnetic Magnetism."

THE LATE MR. THOMAS BOUTS.

THE 1891 group of Whitworth men, which has been depleted during the past year by the deaths of Dr. Walter Lilly and Mr. R. H. Cabena, has recently lost another of its number in Mr. Thomas Bouts, Wh.Ex., who died at his home in Streatham on September 15. Mr. Bouts, formerly chief draughtsman with Messrs. Peek, Frean and Company, Limited, Bermondsey, was born in 1866 and received his early education at Newington Grammar School. He was apprenticed in 1880, for a term of four years, to Mr. F. W. Jackson, proprietor of the Kingsbury Iron Works, Dalston; but this business was discontinued in 1882, and Bouts completed his apprenticeship with Messrs. Archibald Smith and Stevens, hydraulic and general engineers, of Queen's-road, Battersea, with whom he remained until 1888. He then transferred to the steam-launch building yard of Messrs. Miller, Rouse and Tupp, at Hammersmith, but left them in 1889 to undertake a course of study at the Birkbeck Institute and at Onslow College, Chelsea, which resulted in the award to him, in 1891, of the Whitworth Exhibition. Subsequently, he held appointments as draughtsman with the Anti-Friction and Grinding Machinery Company, makers of ice-making and cooling plant; chief draughtsman with Messrs. Henry Pontifex and Sons, brewers' engineers, King's Cross; senior draughtsman, from 1893 to 1898, with Messrs. J. Dewrance and Company, Great Dover-street, S.E.; chief draughtsman with Messrs. Ernest Scott and Company, London; and, finally, in 1911, chief draughtsman at the biscuit manufactory of Messrs. Peek, Frean and Company, from which position he retired at the end of 1932. Mr. Bouts was an associate-member of the Institution of Mechanical Engineers, to which he was elected in 1898.

FOUR-BALL TEST FOR LUBRICANTS.



LETTER TO THE EDITOR.

THE WEAR-LOAD CHARACTERISTIC OF THE FOUR-BALL TEST WITH VARIOUS LUBRICANTS.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Clayton very kindly allowed me to see his remarks, before he submitted them to you for publication in your issue of September 13. Every physicist will agree with him that no useful purpose is served by "speculative juggling with physical and chemical factors." The main purpose of my article in your issue of June 7 was to point out that measurements with the four-ball apparatus lead to a wear-load characteristic, and that on physical grounds, which were dealt with, the appearance of this characteristic must be that of a saturation curve, whereas the wear-load curve should be expected to have a discontinuity if the term "breakdown load," which frequently occurs in the technical literature, would cover more than an unwarranted assumption. It is apparent from Mr. Clayton's letter that he adopted the term without attaching any physical meaning to it, simply for grading various lubricants with respect to their behaviour in a particular testing apparatus. What Mr. Clayton calls the breakdown load of his lubricants is neither a definite load nor an "observational fact," but an arbitrary interpolation of observational data. It is also regarded as futile to apply the term "seizure characteristic," while the engineering term "seizure" lacks physical definition, and it is suggested to be in better keeping with the observational facts to speak about a wear-load characteristic than about a seizure characteristic.

Mr. Clayton does not dispute that the wear-load curve in tests with lubricants can be regarded as consisting of three parts, and that the impression diameter increases to a lesser degree with load in the ranges of comparatively low and high loads than in the intermediate range, but objects to its continuous variation, with the surprising argument that "the drawing of mean lines through plotted points is nearly always somewhat arbitrary, but there is actually little experimental evidence for rounding off the corners at the junctions of the three parts of the wear-load curve in tests with lubricants." There is little doubt that arbitrary straight lines should not be mixed up with experimental evidence and, actually, Mr. Clayton's papers contain a number of curves (see, for instance, your issue of February 9, page 134, Fig. 7A; and *General Discussion on Lubrication*, London, vol. 2, page 40, curve "Oil G"; page 277, curve "Oil A"; and page 280, curves "Plain mineral oil," and "Express engine oil"), where the measured points scattered so little that Mr. Clayton himself indicated rounded off corners. Similarly, the tests without lubricants reproduced in Fig. 4*b*, on page 132 of your issue of February 9, gave results with sufficiently little scattering for Mr. Clayton to raw continuous curves with rounded-off edges through the measured points. Mr. Clayton, in his article, points out the high consistency of these latter measurements, which indicate "no quick progression to a welding seizure," *i.e.*, that there is a continuous transition to the range of rapid wear.

Mr. Clayton mentions in his letter that he was unable to offer a precise explanation of the initiation of seizure and postulates that on this account my remarks on (1) the contrast in behaviour of the extreme-pressure lubricant, E.P. oil E, and other lubricants; (2) the periodic peaks that could be obtained with the friction recorder of the four-ball apparatus; and (3) the comparative influence of the lubricants and the mating surfaces, no longer apply. While I appreciate his statement that he used the words "breakdown load" and "seizure" in a very loose meaning, my remarks refer less to his usage of these words than to what would have to be expected if one were entitled to assume an actual breakdown of the lubricant film by allowing the surface irregularities of the sliding materials to pierce this film and to give rise to metal-to-metal contact with subsequent welded metallic bridges. Periodic peaks, for instance, should be obtained with the friction recorder, if actual breakdown occurred. The facts that they are not obtained and that the nature of the lubricants rather than the material of the mating surfaces determines the shape of the wear-load curve is part of the argument against breakdown and welded bridges. This also answers Mr. F. L. Garton's (your issue of August 9) misunderstanding "that the lubricant should be of much less influence than the material of the mating surfaces."

The thickness of the boundary layer can be reduced either by squeezing out part of it during sliding, or, in the case of porous material, through blotting action. Evidence of the adhesiveness of the residual layer and of its ability to pluck particles out of a surface, is found, for instance, in a paper by Bowden, Leben and Tabor (*The Engineer*, vol. 168, pages 215 and 216, 1939), where a platinum slider is described to have plucked a silver blob out of a silver plate. The sugar-lump experiment affords additional evidence for the case where a porous material reduces the thickness of the boundary layer by blotting action while at rest, instead of by squeezing out part of it during sliding.

The claim has been made (Bowden and Leben, *Proceedings of the Royal Society, A*, vol. 169, pages 371-391, 1939) that when the sliding of metals proceeds by a process of stick and slip, the sliding surfaces will be torn in contradistinction to the result of continuous sliding. The writer, in collaboration with Dr. E. Warlow-Davies, has studied the "stick-slip" analysis of sliding with a "press-fit" technique. These experiments, of which it is intended to publish a full account, show that the occurrence of "stick-slips" during assembling of the press-fit is no indication of tearing, but that, on the contrary, with conditions in favour of bad scoring, assembly of the press-fits proceeds without "stick-slips" and with smoothly increasing pressing-on load. There is evidence to justify the statement that the shearing of oxidised surfaces may occur at other than the oxide interface. If, for instance, a steel press-fit is assembled with a machine oil as lubricant, slow sliding proceeds with pronounced "stick-slips" and without apparent damage to the surfaces. If, however, the elements of the press-fit carry a film of the same machine oil and are heated in a furnace to 193 deg. C. for, say, 1 to 2 hours

before being assembled, they acquire a different friction behaviour. Slow sliding now proceeds smoothly, instead of by a process of stick and slip, while the surfaces suffer severe tearing, as shown by the photograph reproduced on the previous page.

The introduction of dielectric strength into the discussion appears to Mr. Garton to be an unnecessary complication "especially since the effectiveness of the commonly used E.P. dopes is known to be due to their chemical activity in forming a suitable film on the gear surfaces." Apart from further hitherto unpublished evidence, there is the result of Bowden, Leben and Tabor (*Transactions of the Faraday Society*, vol. 35, page 901, 1939) that the addition of 1 per cent. of caprylic acid to mineral oil causes a change from "stick-slips" to continuous sliding. Measurement of the dielectric breakdown strength reveals that addition of 1 per cent. of caprylic acid to "Regelax" lowers its value from 45 kV to 16 kV.

Yours faithfully,

ROBERT SCHNURMANN.

London Midland and Scottish Railway Company,
Research Laboratory, Derby.
September 14, 1940.

ELECTRICITY SUPPLY IN SYDNEY.

THE annual report of the Sydney County Council Electricity Department for the year ended December 31, 1939, marks the end of an epoch. It will be the last with the preparation of which Mr. H. R. Forbes Mackay will be concerned, his retirement having taken place on October 6. Mr. Forbes Mackay has been connected with the undertaking for no less than thirty-one years. It is therefore a little unfortunate that an opportunity should not have been taken to give some statistical record of its growth under his management. As it is, all we are able to say is that the undertaking is one of the largest in the Commonwealth of Australia and that during the last ten years the output has increased from 363,814,800 kWh to 741,181,800 kWh. At the beginning of that period a considerable proportion of the electrical requirements was purchased, but at the present time are all generated in the Council's two stations at Bunnerong and Pyrmont.

The most important engineering event of the year was the erection of a Parsons three-cylinder turbo-alternator with a rating of 50,000 kW and a speed of 3,000 r.p.m. Of little less importance than this was the discussion which took place between the officers of the Council and the New South Wales Department of Railways regarding a proposal to interchange energy on a larger scale than formerly. The object of the discussion was, in fact, to determine the best means of utilising their combined resources of the various bodies concerned by increasing the capacity of the inter-connectors between the stations and also by inter-linking the transmission system. The conference was later joined by the Electric Light and Power Supply Corporation, while before negotiations were completed the Minister for Works and Local Government directed the Electricity Advisory Committee of New South Wales to determine the precautions that were necessary to maintain essential supplies in war time. A Technical Panel was therefore set up and prepared a scheme of interconnection which, if carried out over a period of years, will be justified on an economic basis. This scheme has since been put into operation.

During the year under review the electricity generated at the Council's power stations amounted to 741·2 million kWh, and although this was an increase of 57·3 million kWh over 1938, the transmission losses were reduced from 90·8 million to 79 million kWh. On the basis of the total output, the losses amounted to 11·1 per cent. against 13·8 per cent., while in the preceding ten years the figure did not fall below 14 per cent. The total quantity of electricity sold was 633·4 million kWh, an increase of 66·2 million kWh over 1938, or a percentage of 11·7 per cent. An analysis of sales shows that high-voltage bulk and industrial supplies increased from 107·6 million kWh to 122·9 million kWh, industrial supplies from 196·2 million kWh to 215·8 million kWh, commercial consumption from 95·9 million kWh to 104·6 million kWh, and domestic supplies from 152 million kWh to 175·3 million kWh. There was a decrease in the consumption for street lighting from 15·5 million kWh to 14·8 million kWh. The domestic load now represents 27·8 per cent. of the sales, while the consumers under this heading number 256,035, with an average annual consumption of 2,416 kWh.

The revenue received from all sources was 3,224,929*l.*, and the expenditure amounted to 3,154,036*l.* The average price fell from 1·236*d.* to 1·196*d.* per kilowatt-hour sold and the cost from 1·222*d.* to 1·195*d.* The highest price paid by any one consumer was 5*d.* per kilowatt-hour and the lowest 0·526*d.* by a steel manufacturing company taking a supply under special conditions. The greatest consumption by one customer was 9·2 million kWh, by a brewery company.

LABOUR NOTES.

IN August, the home branch membership of the Amalgamated Engineering Union increased from 422,209 to 430,889, and the Colonial branch membership from 38,148 to 38,390. The number of members in receipt of sick benefit increased from 3,887 to 3,952, and the number in receipt of superannuation benefit decreased from 13,527 to 13,490. The number on donation benefit increased from 457 to 481, and the total number of unemployed members decreased from 2,585 to 2,561.

It is stated in the September issue of the Amalgamated Engineering Union's *Journal* that the report of the organisation for the half-year which ended in June indicates a steady increase in finance and membership. When the year opened the total membership was 413,094 and by the end of June it had increased to 456,132. Therefore, after making all allowances for deaths and exclusions during the six months, 43,038 were added to the membership. In the corresponding period of last year, the increase was 16,657. At the end of June, the combined funds stood at 3,400,126*l.*—an improvement of 216,453*l.* as compared with the figures for the previous half-year and an increase of 456,872*l.* during the last twelve months. In the General Fund, there was, at the end of June, 2,008,349*l.* and in the Superannuation Reserve Fund 1,391,776*l.* Six months earlier the General Fund stood at 1,802,993*l.* and the Superannuation Reserve Fund at 1,380,679*l.*

Commenting upon the foregoing figures, Mr. Smith, the general secretary of the organisation, says that although the figures represent the actual position of the union, "it is essential that all the factors making these financial improvements possible should be taken into account." "With membership continually rising," he adds, "and unemployment among our members negligible, we see no reason but that we shall continue in the same direction. Should, however, the international situation be solved within a reasonable period, we may be compelled to issue reports very different in character."

Mr. Tanner's account of the recent conference with the engineering employers on the subject of wages states that, on behalf of the Amalgamated Engineering Union—and the National Union of Foundry Workers, he presented the case for an increase of 3*d.* an hour on the basic rate, and restoration of conditions existing prior to 1931. He dealt with the claim from three main points: (1) The magnitude of the business and contracts placed with the engineering industry. (2) The magnitude of the profits being made from these contracts. (3) Profits and how much of such profits are being taken by the Government—which is paying for the war. Facts and figures were presented in support of the application. Sir Alexander Ramsay, Director of the Engineering and Allied Employers' National Federation, stated in reply that consideration would be given to the statement and material submitted and that consultation would be necessary with the members of his Federation. The conference was adjourned until a mutually-convenient date.

Mr. Grenfell, the Secretary for Mines, has, it is announced, devised a plan under which work will be found for miners who are idle through the decline in the export trade. Unemployed men will be given an opportunity to transfer to inland districts, where trade and employment are plentiful, and those not transferred will be allowed to accept jobs in munition factories and other industries. Meanwhile, the pits hit by the slump in exports will be helped by a levy which it is proposed to make on all the coal produced in Britain in order to enable them to keep open and ready for the restored demand for export coal when it comes.

"Much is said," writes the contributor of an editorial note to the September issue of the Amalgamated Engineering Union's *Journal*, "about training men for engineering work. We are all for it, provided it is recognised that the best and, indeed, the indispensable form of training is work in the engineering shops. The skilled man is the best teacher and teaches best while he is doing his work. The skilled man on the job, in fact, will have to teach the teachers in order to enable the Government to carry out its own training scheme. For instance, the responsible Minister, in his Parliamentary statement, recognised that the best training is done in the factory. He urged employers to undertake such training and said that he had caused the Labour Supply Committees, the Inspectors of Labour Supply, and the factory inspectors to stimulate employers in every way to undertake the maximum amount of training for both the higher and lower levels of skill. What is this but to say that the skilled men on the job are to do the training of the less skilled?"

"Instructors in engineering," the writer goes on to say, "are required for the Government training centres. It is claimed that these centres are turning out semi-skilled workers within four months. That is not skilled in the sense that this union understands it; and, in any case, the training centres, now increased to 19, but presently to be multipled to 40 and working on treble shifts, require instructors and staff if the output of 100,000 trainees a year is to be realised, let alone the doubling of this output when the goal of 40 training centres is achieved. In making this statement, the Minister said he desired to pay his tribute to this union in the obtaining of instructors. The Engineering and Allied Employers' National Federation had also promised their help, he said; but he urged every engineering employer to consider whether one or two suitable men could be released to become instructors in the training centres. This confirms our point. It is the skilled craftsman on the job and from the job who is qualified to teach the teachers."

The United States Supreme Court has held that the wage requirements, imposed by the Secretary of Labour on companies doing business with the Government under the provisions of the Public Contracts Law, commonly referred to as the Walsh-Healey Act, are not subject to judicial review. In brief, the law requires that contractors on Government work involving 10,000 dols. or over must pay "not less than the minimum wages as determined by the Secretary of Labour to be the prevailing minimum wages for persons employed on similar work or in the particular or similar industries or groups of industries currently operating in the locality in which the materials, supplies, articles, or equipment are to be manufactured or furnished." In January, 1939, the Department of Labour established six prevailing wage areas, or localities, effective as of March 1, 1939, for the iron and steel industry. One of the "localities" in the north-eastern section included approximately 14 States and the District of Columbia. Several independent steel companies who were prospective bidders on Government contracts filed an action attacking the order of the Secretary of Labour and complained against the extent of the "locality." They claimed that the interpretation of the word "locality" embraced such a wide area that it was arbitrary and capricious, and, therefore, would prevent them from competing with larger steel companies. It was their contention that a "locality" meant a local centre of manufacture or a small geographical area surrounding the place of performance of a Government contract.

The Federal Government, on the other hand, asserted that the discretion of the Secretary of Labour in the definition of a "locality" was unlimited. The steel companies failed to obtain an injunction in the trial court, but the Court of Appeals for the District of Columbia finally granted relief. The action of the Court of Appeals, however, was reversed by the Supreme Court in an opinion written by Mr. Justice Black. In his ruling, Mr. Justice Black sustained the contention of the Government that the suit "constitutes an unwarranted interference with deliberate legislative policy and with executive administration vital to the achievement of governmental ends, at the insistence of parties whose rights the Government has not invaded and who have no standing in court to attack the Secretary's determination." In this connection it was pointed out that, in order for the steel companies to have a standing in court, they would have to show an injury or threat to a particular right of their own as distinct from the public interest in the administration of the Walsh-Healey Act. The law, Mr. Justice Black said, "was not enacted for the protection of sellers and confers no enforceable rights on prospective bidders."

The Court further declared that the Government, like private individuals and businesses, enjoys the unrestricted power to produce its own supplies, to determine those with whom it will deal, and to fix the terms and conditions upon which it will make needed purchases. According to the Court's opinion, the Government, acting through its agents, may, for the purpose of keeping its own house in order, lay down guideposts by which its agents are to proceed in the procurement of supplies. The Public Contracts Act, it was pointed out, was not intended to be a bestowal of litigable rights upon those desirous of selling to the Government, but was intended to impose obligations upon those favoured with Government business. Its principal purpose was to "obviate the possibility that any part of our tremendous national expenditure would go to forces tending to depress wages and purchasing power and offending fair social standards of employment."

EVAPORATION OF WATER FROM SATURATED SURFACES.

Fig. 1.

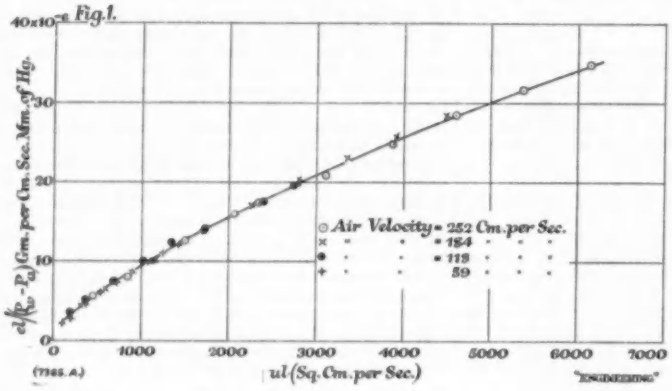


Fig. 2.

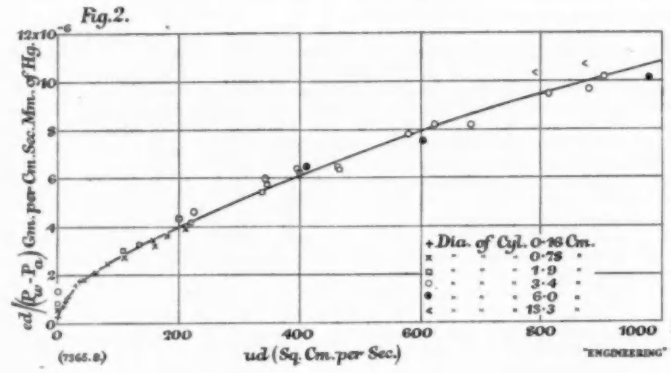


Fig. 3.

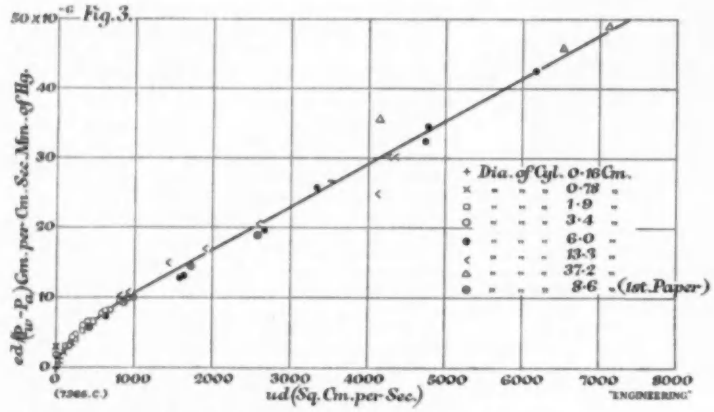
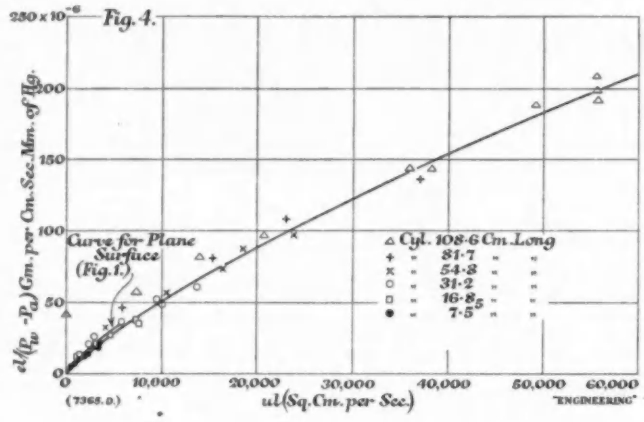


Fig. 4.



THE EVAPORATION OF WATER FROM SATURATED SURFACES.*

By R. W. POWELL, Ph.D.

A PAPER describing some experiments on the evaporation of water into a stream of air was read before the Institution in 1935.† Results were then given for a horizontal plane subjected to a tangential wind stream, and a vertical cylinder subjected to a wind stream at right angles to its axis. In each instance the rate of total evaporation was found to be proportional to $(p_w - p_a)$, the difference in vapour pressure at the saturated surface and the partial vapour pressure in the incident air stream. These experiments were also designed to give information on local variations in the rate of evaporation over the surface. For the plane surface the rate of evaporation was found to be greatest at the leading edge and to decrease from downstream areas in a manner which made the total evaporation from a surface of length l proportional to $l^{0.77}$. For the vertical cylinder the rate of evaporation was a maximum at the front, decreased towards the sides, and again increased to a maximum value at the rear. These experiments were restricted to a cylinder of one diameter. In the present instance, results are given for the total evaporation from several surfaces of various dimensions. The results for each type of surface can be correlated so as to give a single curve from which it becomes possible to deduce rates of evaporation corresponding to a wide range of air velocities and surface dimensions.

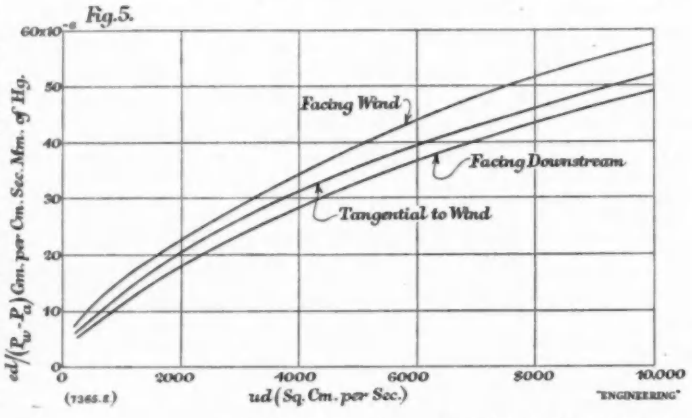
In the case of the plane surface subjected to a tangential wind stream, results have already been obtained for surfaces of various lengths. The previous paper contained data for lengths ranging from 1·8 cm. to 24·3 cm. and air velocities of 59, 113, 184 and 252 cm. per second. In Fig. 1, herewith, it is shown that these data can be brought on to a single curve by plotting the rate of evaporation, due to unit vapour pressure difference, from a surface of unit width and of length l cm., against the product of the air velocity and length of surface.

This method of correlation is analogous to that commonly adopted in problems of heat transfer by forced convection, where dimensional analysis has shown $\frac{h\,l}{k\theta}$ to be a function of the Reynolds number $\frac{u\,l}{v}$; h = heat transfer per unit area, θ = temperature difference between surface and air, and k and v are the thermal conductivity and kinematic viscosity of the air. In the problem of evaporation, $\frac{e\,l\,D}{(p_w - p_a)}$ is a function of $\frac{u\,l}{v}$, where e is the rate of evaporation per unit area, and D is the coefficient of diffusion of water vapour into air. Since the present evaporation experiments were all carried out at approximately the same temperature, D and v can be regarded as constants, and it suffices for $\frac{e\,l}{(p_w - p_a)}$ to be plotted against $u\,l$ as in Fig. 1. Departures from this curve are to be expected when the product $u\,l$ becomes small, for, as l tends to zero, the curve should tend towards the origin, while as u tends towards zero the curve should tend towards the finite value appropriate for natural evaporation.

Most of the experiments described in the present paper were carried out in the wind tunnel used previously, which had the form of a square-sectioned wooden structure of 54 cm. side and 270 cm. length, flared at the intake end to 100 cm. side over an additional length of 60 cm. The water was again retained on the surface under investigation by an outer covering of linen, vellum or filter paper, into which thermocouples were inserted to enable measurements of surface temperature to be made. Direct measurements were made of the loss in weight of water during observed time intervals by weighings made at the beginning and end of each experiment. The readings of wet- and dry-bulb thermocouples located in the incident air stream enabled p_a, the partial vapour pressure of the ambient air, to be determined. The velocity of the air stream was measured by means of a calibrated vane anemometer. The results obtained for various types of surfaces are shown in the form of graphs.

The results obtained for horizontal cylinders about 30 cm. long and ranging in diameter from 0·16 cm. to 37·2 cm., set with their axis at right angles to the air stream, have been plotted in Figs. 2 and 3, above, Fig. 2 covering values of $u\,d$ up to 1,000, and Fig. 3, values up to 7,500. The curves show the rate of evaporation per unit area per unit vapour-pressure difference × diameter, plotted against diameter × air velocity.

Fig. 5.



Since the 37·2-cm. cylinder was too large to be tested in the wind tunnel in the normal manner, the three experimental points shown were obtained when the cylinder was hung from a balance in a long corridor, 6 ft. wide and 9 ft. high. The corridor was open to the atmosphere at each end, and advantage was taken of the draught set up by the prevailing atmospheric conditions. As an alternative means of extending the experiments to high values of $u\,d$, a few tests were made on the 6-cm. diameter cylinder in another wind tunnel, described elsewhere,* in which air speeds up to about 1,000 cm. per second could be obtained. The results of these two experiments are seen to be in reasonably good agreement at values of $u\,d$ of about 6,500. Fig. 3 also includes data from the 8·6-cm. cylinder tested previously, and these agree with the present results. Over the range $u\,d = 40$ to $u\,d = 2{,}000$, the curve drawn in Fig. 3 is represented by

$$\frac{e\,d}{(p_w - p_a)} = 1{\cdot}72 \times 10^{-7}\,(u\,d)^{0{\cdot}6}. \quad . \quad (1)$$

The cylindrical surface used for these experiments

* Paper read before the Institution of Chemical Engineers, London, on Friday, March 8, 1940. Abridged.

† R. W. Powell and E. Griffiths, *Trans. Inst. Chem. Engrs.*, vol. 13, page 175 (1935).

* E. Griffiths and J. H. Awbery, *Proc. I. Mech. E.*, vol. 125, page 319 (1933).

EVAPORATION OF WATER FROM SATURATED SURFACES.

Fig. 6.

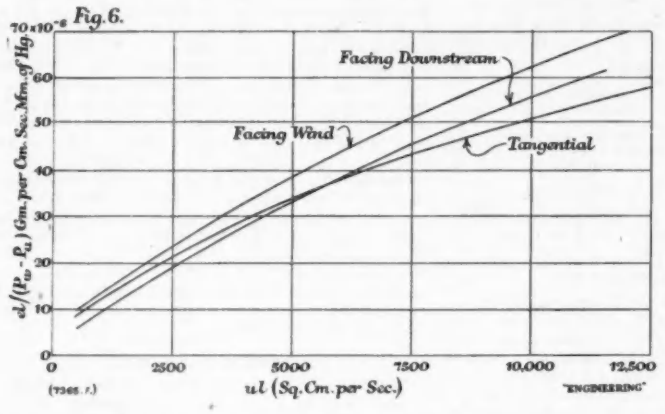
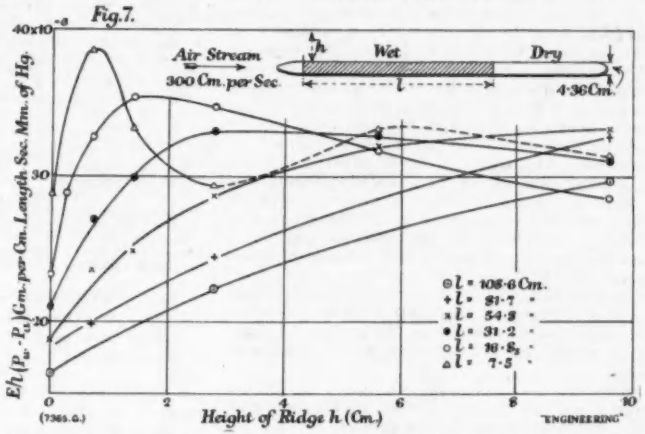


Fig. 7.



consisted of a glass tube having the ends closed by streamlined wooden end-pieces and the surface wrapped with linen. The final external diameter was 4·36 cm., the length of wetted surface 108·6 cm., and of the dry nose, 9 cm. In the course of the experiments, the effective length was reduced from the downstream end by covering sections of the surface with aluminium foil. The results obtained for wetted lengths ranging from 7·5 cm. to 108·6 cm. are shown in Fig. 4, opposite, which also includes the curve given in Fig. 1 for the plane surface. As before, this curve shows the rate of evaporation per unit area per unit vapour-pressure difference × length, but plotted this time against length × air velocity. In drawing the curve through the points obtained with the cylindrical surface, weight has been given to those obtained at velocities above some 180 cm. per second, since deviations due to natural evaporation become evident at lower velocities. The equation of this curve is

$$\frac{e\,l}{(p_w - p_a)} = 3{\cdot}17 \times 10^{-6}\,(u\,l)^{0.8}. \quad . \quad (2)$$

The order of agreement over an extended range of values of u and l between results given by this curve and those derived from the equation

$$E = 2{\cdot}12 \times 10^{-7}\,l^{0.77}\,(p_w - p_a)\,(1 + 0{\cdot}121\,u^{0.85}) \quad (3)$$

obtained for a plane surface previously tested, can be seen from the data given in Table I, below.

TABLE I.—*Evaporation Rates per Unit Width of Surface, Using Equations* (2) *and* (3).

Air-Velocity, u (cm. per sec.).	Length of Surface, l, cm.	Equation (3).	Equation (2).	Difference, Per cent.
100	20	$1{\cdot}50 \times 10^{-5}$	$1{\cdot}39 \times 10^{-5}$	−7·9
	60	3·50	3·34	−4·8
	100	5·19	5·02	−3·4
	1,000	30·57	31·70	3·6
500	20	5·28	5·02	−5·2
	60	12·31	12·10	−1·7
	100	18·24	18·21	−0·2
	1,000	107·5	114·9	6·4
1,000	100	32·3	31·7	−1·9
	1,000	190·1	200·0	5·0

Measurements have been made of the evaporation of water from circular discs of saturated materials when supported on thin metal plates of practically the same diameter as the evaporating surface. The moistened surface covered one side of the metal plate only. The discs had diameters of 5·4, 11·0, 15·6 and 22·1 cm., and were subjected to an air-stream directed normally on to the wet surface. Modifications in the experimental method and in the nature of the absorbent medium had little influence on the values obtained.

The results also conformed closely to a single curve, represented approximately by the equation

$$\frac{e\,d}{(p_w - p_a)} = 3{\cdot}3 \times 10^{-7}\,(u\,d)^{0.65} \quad . \quad (4)$$

from which it follows that the rate of total evaporation is proportional to $d^{1.56}$. Measurements on these four discs have also been made with the disc mounted on the surface of the plate which faces downstream, and for the position at right angles to this, in which the air stream is directed tangentially over the surface. The mean curves obtained for the three positions are drawn in Fig. 5, opposite. For the range of values of $u\,d$ which have been investigated, the extreme differences in the rates of evaporation for these three positions are not very considerable and decrease from 40 per cent. for a value of $u\,d$ of 500 to only 17 per cent. when $u\,d$ reaches 10,000.

Experiments were made in each of the three principal directions for a number of rectangular surfaces. These were mounted to have the surface in a vertical plane, and while the height b of the surface was kept constant at a value of 19·4 cm., the width, l, or the length as measured in the direction of the wind for the tangential setting, had values of 3·9, 8·8, 19·4 and 26·7 cm. Fig. 6, on this page, shows the mean curves obtained for the three positions when $\frac{e\,l}{(p_w - p_a)}$ is plotted against $u\,l$. In this instance the curve for the tangential position is intermediate between those for the two perpendicular positions for values of $u\,l$ below 5,400, but above this value it gives the lowest rate of evaporation. The curve given in Fig. 6 for the tangential position can be compared with that obtained in the earlier investigation and represented in Fig. 1. The former curve indicates a higher rate of evaporation. The increase, which amounts to about 30 per cent. at $u\,l = 1{,}000$ and 10 per cent. at $u\,l = 6{,}000$, is probably explained by the absence of a specially-shaped leading-edge in the later experiments. At slow air speeds it is also possible that natural convection currents set up by the cool evaporating surface have a greater influence on the rate of evaporation from a vertical than from a horizontal surface.

The rate of evaporation from a plane surface can be increased by means of ridges, which introduce additional turbulence into the air stream passing over the surface. A more detailed investigation of this effect has been undertaken for the case of the 108·6-cm. cylinder. For each length of surface, tests were made with ridges in the form of thin collars fitted at the junction of the streamlining nose and the wet surface. Several of these collars were used, which projected at right angles to the surface to distances varying from 0·25 cm. to 9·6 cm. The data plotted in Fig. 7, which apply to an air-speed of 300 cm. per second, were obtained from the smooth curves drawn through these experimental results. In this figure the rate of evaporation per unit length of the cylindrical surface is plotted against the height of the projecting ridge, curves being drawn for each length of surface studied. As the length of the surface is diminished, the results show that there is an optimum height of ridge for which the total evaporation from a particular length of surface is a maximum. For surface lengths of 31·2, 16·8 and 7·5 cm., these heights are approximately 2·8, 1·5 and 0·7 cm., respectively. The curve for the 7·5-cm. surface is shown partly dotted, as the experimental results could not be reproduced so closely when the larger ridges were used.

The earlier results showed that the presence of the ridge causes shielding of the surface immediately behind it, then comes a region of maximum evaporation, where, presumably, the surface is swept by the turbulent eddy of air set up by the ridge; this is followed by a region farther downstream where the rate of evaporation decreases with distance. The optimum height of ridge is, no doubt, that consistent with the maximum length of surface being swept by the eddying air, further increase in height leading to excessive shielding of the surface. At an air speed of 300 cm. per second, a ridge 2·8 cm. in height is seen to increase the evaporation from the first 31·2 cm. of the cylinder by 57 per cent., and that from the remaining 77·4 cm. by 22 per cent., while a ridge 1·4 cm. high increases the rate of evaporation from the first 17 cm. of surface by about 50 per cent., and that for the remainder of the surface by about 10 per cent. It would seem that an increased rate of evaporation can be obtained from a long surface by the use of a series of ridges separated by distances consistent with the maximum effect being obtained from each ridge. This was verified by an experiment in which three ridges, each 2·8 cm. high, were equally spaced alone the 108·6-cm. cylinder. The rate of evaporation per unit length at an air speed of 300 cm. per second was then found to be 32×10^{-4} gm. per second per millimetre of Hg, which is 44 per cent. greater than the value obtained when only one ridge of this size was used. Even when the rate of evaporation is increased in this way, it is still less than the value of 40×10^{-4} gm. per centimetre length per second per millimetre of Hg, which would be obtained at the same air speed if the conditions permitted the cylinder to be set with its axis at right angles to the air stream.

Tests have also been carried out on the plane rectangular surfaces for a number of intermediate orientations. With the surface facing the air stream, the results for these intermediate positions merely showed a gradual transition from those for the tangential position to those for the normal position. When, however, the wet surface was mounted on the downstream surface of the plate, it was possible to obtain greatly increased rates of evaporation for certain orientations which take advantage of the stream of turbulent air set up by the leading edge of the inclined plate.

(To be continued.)

WATER SUPPLY ON THE RAND.

THE thirty-fifth annual report of the Rand Water Board for the year ended March 31, 1940, shows that satisfactory progress is being made by this important undertaking. Its constituent authorities, to which water is supplied in bulk, comprise the South African Railway Administration, twelve local authorities, of which Johannesburg, with a population of 537,217, is the largest, and the Transvaal Chamber of Mines. In addition, a number of other municipalities and undertakings are supplied, including the Victoria Falls and Transvaal Power Company, Limited, and the African Explosives and Industries, Limited, as well as various ungrouped mining companies and several small consumers. The population within the municipal areas is 1,116,958, of whom 657,139 are non-Europeans, and the total area is 472·84 square miles. The Board's sources of supply consist of the Vaal River, from which 150 million gallons a day can be abstracted, as well as a series of boreholes in the Klip River Valley and wells at Zuurbekom. Actually, the net capacity of the mains for pumping into supply, after making deductions for leakage and wastage, was 68,000,000 gallons a day, while the total quantity of water raised from all sources during the year under review was 17,536,234,000 gallons, as compared with 15,666,498,000 gallons during 1938-39, an increase of 1,869,736,000 gallons. The total quantity sold was 16,983,648,000 gallons, compared with 15,175,724,000 gallons in the previous year, an increase of 4,824,444 gallons a day. The water unaccounted for amounted to 291,392,000 gallons, or 1·687 per cent., as compared with 1·564 per cent. during the previous year. This percentage included leakage, water used in cleaning reservoirs and scouring mains, evaporation, and errors in metering.

It should be pointed out that the rainfall in the district, which was 35·25 in. during the year under review, compared with an average of 32·8 in. for the past fifty-one years, is comparatively low. The winter rainfall was 8·31 in., and the summer rainfall was 26·94 in., or 76·43 per cent. of the total. The rainfall, it may be added, is distributed fairly evenly over the area. The Board's service reservoirs, of which there

are twelve, are located at the pumping stations and at high points along the Witwatersrand. Their principal object is to facilitate distribution and until a year or two ago they did not provide more storage than was necessary to assist in meeting the peak demand. At present, including those owned by the Johannesburg and Krugersdorp municipalities, the total storage capacity is slightly in excess of 100 million gallons, a figure which was reached during the year under review by the construction of a reservoir with a capacity of 2,500,000 gallons at Libanon, about 30 miles south-west of Johannesburg. In addition, seven other reservoirs, with a total capacity of 31·5 million gallons, are controlled by the Johannesburg municipality and are supplied with water by the Board. This system of reservoirs is completed by 448 miles of pipe lines, 435 miles of which are pumping and gravitation mains, the remaining 13 miles being collecting mains from boreholes and wells. The system extends from the Vaal River at Vereeniging to the Central Rand, a distance of 36 miles, and along the Witwatersrand from Libanon on the west to Nigel on the east, a distance of 80 miles.

During the year, 33 miles of new or of reconditioned pipes were laid and 7 miles of old mains were lifted. The Vereeniging-Zwartkopjes connection was strengthened by the laying of 95,000 ft. of 54-in. diameter pipe-line, while 17,000 ft. of old 27-in. diameter pipe, between Turffontein Nek and the Central area, was replaced by laying 15,800 ft. of 48-in. diameter pipe and 1,000 ft. of 29-in. pipe. The line from Forest Hill to Village was also completed by laying 20,000 ft. of 48-in. pipe and a cross-connecting pipe line, consisting of 750 ft. of 16-in. diameter pipe, was laid between the 24-in. Signal Hill and the 16-in. Simmer and Jack-Leeuwpoort pipe lines, to improve the supply into the Germiston area.

As regards pumping arrangements, water is drawn from the barrage impounding reservoir of the Vaal River to the Vereeniging main pumping station, where it is purified and pumped to the Zwartkopjes pumping station. The normal pumping head between Vereeniging and Zwartkopjes is 530 ft., but including the head on the river at the pumps the total head required is 650 ft., and the distance between the two points is about 30 miles. Actually the pumping head is considerably less than normal, as the designed capacity of the pipe lines has not yet been reached. The Zwartjopjes pumping station, which is located in the Klip River valley to the south of Johannesburg, repumps the whole of the water derived from the Vaal River for distribution on the Witwatersrand. The distribution reservoirs are situated at Yeoville, Forest Hill and Benoni, the normal head in the first case being 1,300 ft. and 1,150 ft. in the second and third. The Zuurbekom pumping station, which is situated about 16 miles south-west of Johannesburg, obtains its water from boreholes and wells. This water is pumped directly into the supply system and serves principally the areas in the West Rand and the Libanon district.

The chief engineer reports that the water of the general supply was maintained in a highly satisfactory condition throughout the year. On 249 days samples were examined in quantities of 100 cub. cm. for coliform organics, and on no occasion were any found to be present. As in previous years, the water from the Zuurbekom boreholes was of high clarity and excellent bacterial purity, but chlorine was added at the average rate of 0·147 pint per million as a precautionary and security measure. Owing to the construction of the Vaal bank dam, it has been found that the water in the Vaal River, even at times of flood, did not carry such high quantities of suspended matter as previously and did not clear during the winter-spring period to the extent that it previously did. In fact, the average proportion of suspended matter increased from four parts per 100,000 in 1937-38 to 21 parts in 1939-40. The 16·6 million gallons taken from the river carried 17,368 metric tons of suspended solid matter, which was removed in sedimentation tanks and filters, and at no time during the year did the water clear sufficiently to make it economical to treat it with aluminium sulphate alone. Clarification was, therefore, effected with lime as the primary and aluminium sulphate as the secondary coagulant.

During the year the hardness of the river water remained low, except during short periods of high floods. At times the clarification treatment raised the hardness, but never by more than the equivalent of one part of calcium carbonate per 100,000, and during most of the year it effected some softening. As a result, the water sent into supply had a hardness varying between six parts and eight parts of calcium carbonate per 100,000, and on only 14 days did the hardness exceed 8·5. On only three days did the hardness exceed 12, and the maximum prevailed for only one day. The 16,602 million gallons taken from the river yielded 15,737 million gallons of purified water for distribution, the difference of 5·21 per cent. being accounted for by water used in sludging and filter washing.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, etc., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

HYDRAULIC APPARATUS.

521,609. Pipe-Joint Clamp. P. G. Johnson, of London. (6 *Figs.*) November 22, 1938.—The invention is an adjustable clamp for pipe joints, particularly for sealing leaking spigot and socket joints, made with lead in large cast-iron or steel pipes. The front flange 1 of the clamp is composed of several malleable cast-iron or cast-steel segments 2, each connected to its neighbours by adjustable connections 3. The general cross-section of the flange 1 (Fig. 1) consists of a conical main web 4 with an inward lip round the pipe for compressing the packing against the socket face and also radially inwards against the spigot. Bolts 10 draw up the front flange to the anchor collar 11. At each connection, the web 4 of one segment is extended and cranked to overlap the web of the other segment for a short distance. On the

Fig. 1.

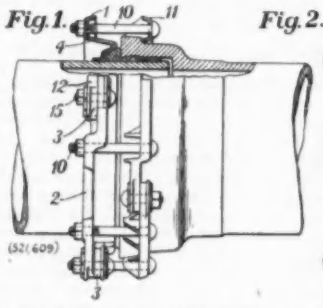
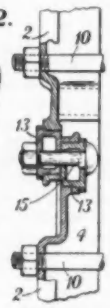


Fig. 2.



webs at the ends of the segments are robust eyes 12 which lie side by side when the segments are in position. In each eye is a rotatable bush 13 with eccentric holes through which passes a common pivot bolt 15. When the bushes 13 are located with their eccentricities in the same direction, there is an intermediate degree of separation of the segments 2. If this gives too large an annulus for a certain pipe, the separation can be completely eliminated by turning the bushes in opposite directions, each through 90 deg. If the annulus is not large enough, the separation can be increased to a maximum by turning the bushes, again in opposite directions, in the respectively reverse senses. The bushes are locked by tightening the nuts on the pivot bolts 15, the contacting surfaces of the bushes being serrated to give increased grip. (*Accepted May* 27, 1940.)

STEAM ENGINES, BOILERS, ETC.

521,081. Locomotive Valve Gear. Caprotti Valve Gears, Limited, of London (*J. J. Kupka, of New Brunswick, U.S.A.*). (3 *Figs.*) November 18, 1938.—The Walschaert valve motion shown in Fig. 1 combines the motion obtained from the crosshead 2, which imparts to the distributing valve a constant travel equal to the

Fig. 1.

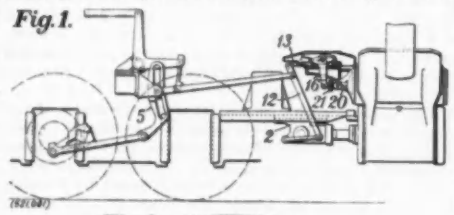
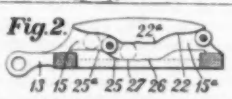


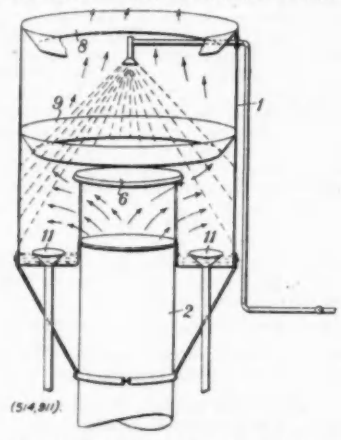
Fig. 2.



lap plus lead, with the motion derived from the main eccentric pin which imparts to the valve a variable travel corresponding to the greater or lesser time of admission of steam to the locomotive-engine cylinder obtained by moving the block in the oscillating link 5 by the reversing gear. With the present invention a further motion is introduced whereby the speeds of opening and closing of the valve are accelerated and decelerated as compared with those obtained at present. A reciprocating member 13 is attached to the combination lever 12 of the Walschaert gear and slides in rigid guides attached to the cylinder. In this member are slots 15 and 15*a* (see Fig. 2) shaped to give the requisite motion to a rocking member 16. This rocking member 16 is of T-shape, having a fulcrum central to the head of the T, while the ends of the head carry rollers which ride in the slots. The foot of the T is connected to the valve spindle 20 by a short connecting link 21. The movement and the acceleration of the valve are determined by the shape of the faces 22 and 25, and the deceleration by that of the faces 25*a*, 22*a* for the period when the valve is being drawn towards the crosshead end of the cylinder. The motion of the valve plotted on the base of the piston stroke is, in the ordinary gear, an ellipse, but with the addition of this device the faces 26 and 27 can be arranged to hold the valve fully open in a stationary position. Thus the diagram would be rectangular with elliptical ends. The shape of the faces which give the acceleration and deceleration, must be carefully worked out to match the motion given to the reciprocating member 13 by the particular valve gear. (*Accepted May* 10, 1940.)

MISCELLANEOUS.

514,911. Soot Arrester. Grit Abaters, Limited, of London, and W. G. Hegbourne, of London. (2 *Figs.*) May 18, 1938.—The invention is a dust and soot collector for chimneys. A collecting chamber 1 is attached to the chimney piece 2. Gases from the chimney are passed through the chamber where they meet a water spray. The spray is divergent so that the jets of water are directed against the sides of the chamber about the level of the chimney opening. The gases are deflected outwards by a baffle plate 6 carried on the chimney top, and they therefore traverse the spray and finally strike against that



part of the chamber wall which is continuously wetted by the spray. The upper end of the chamber is open to the atmosphere but the upward flow of the gases is retarded by inverted conical baffles 8 and 9, one at the opening and the other immediately above the baffle 6. The baffles form pockets which arrest the heavier particles. The bottom of the chamber provides a collecting sump for the extracted soot. Overflow openings 11 are provided through which the water is led away to the base of the chimney. If the nozzle is arranged to direct the spray so that the area against which the gases issuing from the chimney impinge is continuously wetted, the continuous trickle of water assists to collect the soot.—(*Accepted November* 21, 1939.)

519,773. Shaft Coupling. Metalastik, Limited, of Leicester, and M. Goldschmidt, of London. (7 *Figs.*) August 3, 1938.—The purpose of the coupling is to allow relative angular displacement of a pair of coupled pipes or shafts while resisting their axial displacement by compressing parts of rubber. A pair of annular rings 12, 13 are vulcanised to the rubber block 14 between

Fig. 1.

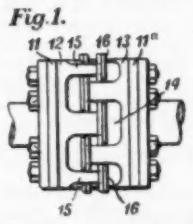
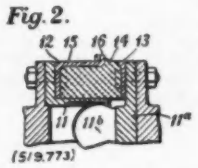


Fig. 2.



them, and parts of their cylindrical flange 15 are bent out to form lips 16. These lips are partly embedded in the rubber and so offer an additional resistance to axial displacement of the two rings 12, 13, which are bolted to flanges on the shafts. A flanged sleeve 11 and a disc 11*a* are inserted between the rings 12, 13 and the shaft flanges. The disc carries a ball 11*b* guided in a recess in the sleeve to allow slight angular displacement of the shafts. (*Accepted April* 5, 1940.)